KARNAK BULLETIN NO. 6

WATERPROOFING METHODS AND MATERIALS

KARNAK

TRADE MARK

GARDINER & LEWIS, INC.

CHICAGO
6 NORTH LA SALLE STREET

NEW YORK
30 CHURCH STREET

KARNAK

UNALTERABLE PRODUCTS

Built up to a Standard
Not down to a Price

It is an accepted scientific fact that it is entirely possible by means of the standard A.S.T.M. tests, to predetermine the quality and serviceability of bituminous materials for waterproofing and roofing work.

Karnak materials are tested at the factory by independent testing laboratories before shipment. These laboratories affix to each package their label or seal identifying the package so marked with their tests. A copy of the test will be sent direct to the architect or engineer.

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FOREWORD

The object of this booklet is threefold, viz.,

1. To place before intelligent readers accepted and thoroughly authenticated facts and data on bituminous materials, so that such readers may exercise a proper discrimination in writing a waterproofing specification calling for such materials.

2. To promote, not a trade name alone, but the quality of material as measured by standardized methods, that the trade name represents.

3. To augment the interest in KARNAK materials and to stimulate their sale.

The foundation of the discussion that follows is this:

Wherever our technical societies—the American Society for Testing Materials, The United States Bureau of Standards, The American Society of Civil Engineers—have set up and standardized a series of tests designed for the purpose of determining the quality and serviceability of any structural material,—those tests should be the basis on which that material is bought and sold. As such a series of tests have been set up for bituminous materials it is from the standpoint of these tests that this discussion proceeds.

We do not discount nor minimize the value of the trade name. On the contrary we value our own trade name very highly. But whatever real value our own or any other trade name may have, rests on its identity with a positive quality of material as measured by standardized tests. Destroy that identity and the value disappears. Trade names have yet to keep water out of concrete. It is the quality of material that is effective, and that quality is determined not by what it is called but by what it is.

The name KARNAK on waterproofing means this:

1. That both fabric and asphalt delivered on the work have been tested by an independent laboratory, and that they comply in every respect with the specifications for KARNAK materials enclosed in this booklet.

2. That each package of specification material delivered is marked with the label or seal of the testing laboratory, indicating that it has been tested, inspected and passed, the seal bearing a key number by which the package may be identified with the particular laboratory test.

3. That the consumer, i. e., the architect or engineer, will receive without any action on his part, an original test report on his particular shipment direct from the laboratory, giving all of the required tests for comparison with the specifications in this booklet.

The quality of KARNAK materials is fully described in the folder of specifications enclosed in this booklet.

THE FUNCTION OF WATERPROOFING

Any discussion of waterproofing materials that makes even a pretense of technical exactness, must begin with the purpose of waterproofing,—the function that it performs in a structure. The two commonly understood functions of structural waterproofing are to exclude water from an enclosed area as in the case of a building foundation, and to confine water in enclosed areas such as swimming pools, or reservoirs, or channels. These are highly important functions. But there is also another purpose in the use of such materials which is hardly if at all subordinate. That purpose is one of insurance, to protect concrete from the deteriorating effects of water penetration. Our ablest authorities on concrete and reinforced concrete agree that of all the agencies that attack concrete water must be the most seriously considered; and that water is the direct cause of more failures of concrete than any other one factor.

Water is the universal solvent. Passing through concrete it does solve out certain of its constituents. It exerts a greater effect on the change in volume of concrete than does heat or cold. It therefore causes internal stresses which cannot be calculated, the effect of which frequently cannot be guarded against. In planning the waterproofing on any structure both of these functions of waterproofing should be considered, and the final plan should be such that water is excluded from the enclosed area or confined in it as the case may be, and is prevented from penetrating the concrete forming this area.

METHODS OF WATERPROOFING

There are two general methods of structural waterproofing—the integral and the membrane. Of these we advocate only the membrane method. As this booklet is designed to set forward scientific facts, the reasons for our position should be mentioned.

THE INTEGRAL METHOD

The integral method of waterproofing has the advantages of minimizing excavation, of cheapness and simplicity of application. It is, however, an interesting commentary on the three forms of materials used in this method — paste, powder and liquid—that the literature of the manufacturers of each one almost invariably condemns the other two as being inadequate and insufficient. It is a further outstanding fact that no such material has ever received the endorsement or even the approval of any of our technical societies or associations devoted to the study and investigation of building materials. On the contrary, all such bodies unite in recommending that it be not used. The most recent development of this character is the progress report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete representing the following societies:

The American Society of Civil Engineers
The American Society for Testing Materials
The American Railway Engineering Association
The Portland Cement Association
The American Concrete Institute

On the subject of waterproofing, the following appears in the above progress report:

CHAPTER IX

A. WATERPROOFING

79. Integral Compounds shall not be used.
80. Membrane waterproofing shall be used in basements, pits, shafts, tunnels, bridge floors, retaining walls, and similar structures, where an added protection is desired.

As this booklet is a technical discussion of materials, and as reliance for the facts and data presented has been placed entirely on the opinion and accumulated knowledge of both our technical societies and our best independent authorities, we feel justified in omitting further reference to the integral method in all of its phases or forms because of the lack of support which this method has in the independent, technical world. This booklet will therefore deal entirely with the membrane system.

THE MEMBRANE METHOD

The membrane method is based on sound theory and centuries of successful practice. It simplifies construction through having the waterproofing independent of joints. It does not fail if a crack develops. And what is of the greatest importance it has the unqualified endorsement of every technical society in America that deals with construction materials.

Its success depends on two factors, viz.: a proper selection of materials and efficient workmanship. The first is entirely a matter of specifications and their enforcement; the latter, of selecting a suitable and experienced contractor whose ability to handle the character of work involved has been thoroughly established.

CHOICE OF MATERIALS

The principles on which an intelligent choice of materials are based are:

1. An appreciation of the physical properties a material must have in order to function properly.

2. A knowledge of the properties of the materials available for this purpose.

3. The relation between the physical properties desirable and the permanence of the material.

These principles find their definite expression in the Standard Tests for Bituminous Materials of the American Society for Testing Materials on which KARNAK Specifications are based.

It is a well recognized fact that our technical societies—among which we might mention the American Society for Testing Materials, The American Society of Civil Engineers and the United States Bureau of Standards—have set up and standardized a series of tests for bituminous materials by which their quality and serviceability may be predetermined with all reasonable accuracy.

On this point the following opinions from leading independent sources are, we think, sufficiently conclusive.

Committee S-2 of the American Concrete Institute, in a report submitted to the Institute in February, 1922, stated:

> "The American Society for Testing Materials and the American Society of Civil Engineers have established standard tests for bituminous materials and have described in minute detail how such tests shall be made. From these tests it is entirely possible to predetermine with considerable accuracy how bituminous materials will behave in service and the relative life that may reasonably be anticipated from them. Therefore, reliance should not be placed on trade contentions of a material of inexplicable composition. Through lack of proper investigation the profession has been badly misled. Specifications can and, in the opinion of your committee, should be written which describe by standard tests previously mentioned the quality of the material desired just as the quality of the aggregates, cement, steel and other materials is described."

This statement is fully borne out by the following letters from accepted independent laboratories.

Dr. Milton L. Hersey, President, Consulting Chemist to Quebec Gov't.
Roy Geddes, Treasurer
Joel B. Saxe, Secretary
Jas. G. Ross, Consulting Mining Engineer
Charles A. Mullen, Director of Paving Department
Robert Job, A.B., Vice-President
C. R. Hazen, M.Sc., Vice-President

MILTON HERSEY Co. Ltd

INDUSTRIAL CHEMISTS, ENGINEERS AND INSPECTORS

MONTREAL — WINNIPEG

ANALYSES AND ASSAYS
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DESIGNING AND INSPECTING OF ASPHALT PAVING

84 ST. ANTOINE STREET,

TELEPHONE (HEAD OFFICE) MAIN 8718
CABLE ADDRESS—"MILHERSEY—MONTREAL"
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MONTREAL

January 15th, 1923.

Gardiner and Lewis,
Asphaltic Waterproofing Products,
30 Church street, New York.

Dear Sir;- Re: SPECIFICATION REQUIREMENTS FOR BITUMINOUS PRODUCTS.

Replying to your letter of December 27th, 1922.

Our experience has been that those selling bituminous products under trade-name unaccompanied by specifications based on laboratory tests are apt to be peddling wares which will not meet the standard tests for good quality and suitability to purpose. This is sometimes due to the ignorance of party offering goods for sale; sometimes to something worse. The results are equally disastrous to the purchaser in either event.

There are no trade secrets of any value in the field of bituminous materials such as those used for waterproofing, roofing, paving, and so on, as far as I am aware; and the salesman who tries to impute mystical qualities to the product he is selling should be looked upon with grave suspicion. The best materials are always sold under the most open declaration of their source, the process of manufacture, and the qualities of particular grade of product offered to the customer for his special use.

The tests you mention in your letter,- those to show purity, melting point, consistency or penetration, ductility, and volatility,- are standard tests for bituminous materials, other tests being used in some cases for special purposes.

We suggest that the flash and burn test is also essential. The flash point indicates the volatile material in the bitumen and the danger point in manufacture and application, and the burn test is of special value in connection with roofing where there is a fire hazard and the ignition point is important. The paraffin naptha solubility test should also be included in the routine, in order to indicate the type of material used, as the asphaltic products usually show a higher percent of material insoluble in paraffin naptha than do the paraffin oil products.

Yours very truly,

MILTON HERSEY COMPANY, Limited,
Adams and Mullen,
By C. A. Mullen
Charles A. Mullen,
Director of Paving Department.

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CHEMICAL DEPARTMENT
H. H. CRAVER, MANAGER

SUBJECT

January 13th, 1923.

PLEASE ADDRESS ALL COMMUNICATIONS TO THE COMPANY AND REFER TO FILE NO.

Gardiner & Lewis,
30 Church Street,
New York, N.Y.

Gentlemen:

Replying to your recent inquiry, we would state that in our opinion the quality and suitability of bituminous materials for waterproofing can be established by laboratory tests.

The results of many years work with bituminous materials for pavement construction has developed the fact that material satisfactory for paving purposes will comply with standard laboratory tests. Experience has shown that material which has failed to comply with the same tests is liable to produce unsatisfactory pavement.

After considerable investigation by the American Society for Testing Materials and other workers, the following tests have been selected for testing waterproofing materials:

- Softening Point
- Penetration at 25°C, 100 grams, 5 seconds
- Penetration at 0°C, 200 grams, 60 seconds
- Flash Point, open cup
- Loss on Heating 50 grams at 163°C, 5 hours
- Penetration at 25°C of the Residue after heating at 163°C
- Ductility at 25°C
- Insoluble in carbon disulphide

There is no doubt in our mind as to the advisability of testing bituminous water-proofing materials. Such procedure insures uniformity and eliminates guess work. Where a certain material gives satisfaction for a particular purpose, it enables the purchaser to duplicate his order. It is just as important in construction work as in manufacturing practice to know the nature of the materials being used.

Very truly yours,
PITTSBURGH TESTING LABORATORY,
H H Craver
Manager Chemical Department.

HHC/BH

LESTER KIRSCHBRAUN
HUGH W. SKIDMORE
GENE ABSON
DIRECTORS
CHICAGO PAVING LABORATORY, INC
CONSULTING AND INSPECTING ENGINEERS
160 N. WELLS STREET CHICAGO

TELEPHONE MAIN 2558

January 3, 1923

Gardiner and Lewis
30 Church St
New York City

Gentlemen:

* *

The judicious selection of asphaltic materials for a given purpose is predicated upon a thorough knowledge of the physical and chemical properties of the various materials available with respect to the actual conditions imposed by service upon the finished product. The testing of asphaltic materials has developed until proper interpretation of results together with a thorough understanding of the signifigance of those results which are of genuine merit, supplies the expert with sufficient data for the predetermination of the quality and serviceability of the product.

While there are other numerous and varied tests to which asphaltic materials have been subjected at times, we are of the opinion, that aside from the scientific value of some of these tests, the following when conducted in accordance with accepted standard practice and properly interpreted, will be entirely sufficient to qualify or disqualify an asphaltic material for a wide range of uses; particularily the waterproofing, roofing and paving industries

- Penetration @ 32, 77 and 115°F
- Ductility @ 77°F
- Melting point (Ball & Ring method)
- Flash point (open cup)
- Volatilization @ 325°F
- Loss in penetration
- Solubility in CS_2 or CCl_4

The actual limits of each of the above tests to be applied to materials for a given use should be establised by those especially qualified to judge by merit asphalts for such intended purpose. The determination of qualifying limits should include due consideration for the fact that individual tests per se, are not a criterion; but, that the inter-relation between the various tests in the group must be consistent. Each test bears a definite relationship to the others in the group both individually and collectively; consequently the selection of the material having the most agreeable combination of properties depends upon a complete series of tests before judgement is justified.

Very truly yours,

CHICAGO PAVING LABORATORY, Inc
By Gene Abson
Chief Chemist

GA:S

DOW & SMITH

CHEMICAL ENGINEERS CONSULTING PAVING ENGINEERS PETROLEUM TECHNOLOGISTS

SOUTHERN OFFICE
1327 MAIN ST., COLUMBIA, S. C.
T. KEITH LEGARÉ
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DISTRICT MANAGER

ANALYSES—INSPECTION—REFINERY DESIGN AND OPERATION
SPECIFICATIONS—EXPERTS IN COURT CASES
GENERAL OFFICES: 131-3 EAST 23RD STREET
TELEPHONE 3351 GRAMERCY

A. W. DOW, PH. B.
MEM. AM. INST. CHEM. ENGRS.
F. P. SMITH, PH. B.
MEM. AM. SOC. CIVIL ENGRS.
MEM. AM. INST. CHEM. ENGRS.

NEW YORK, March 7, 1923.

Gardiner & Lewis, Inc.,
30 Church Street,
New York City.

Gentlemen:

In reply to your letter of recent date, we beg to say that we are in entire accord with your ideas. The tests on bituminous roofing and waterproofing materials and their relations to the working of such materials in practice are now so well established that there is no longer an excuse for not buying them under specifications calling for certain physical properties which can readily be determined by tests. Such specification is the only way to secure uniformity, and if at any time it is desired to duplicate any particular work, it can readily be accomplished by calling for materials with the same physical properties. The tests which we believe necessary are:

Bitumen soluble in carbon disulphide
Penetration at 32°F.,
" " 77°F.,
" " 115°F.,
Ductility at 40°F.,
" " 77°F.,
Softening Point (Ring and Ball method),
Weight Loss on Heating for 5 hours at 325°F.,
Loss in Penetration occasioned by this heating,
Ductility of the material after being heated at 325°F. for 5 hours.

All of the above tests have been carefully investigated by the American Society for Testing Materials and have been adopted by this Society as either Standard or Tentative Standard.

The properties of asphalts that these tests disclose are as follows:

Bitumen soluble in carbon disulphide. This test gives the amount of material insoluble in carbon disulphide, which is inert and foreign, and therefore which must be considered in the interpretation of other tests.

Penetration at 32°F., 77°F. and 115°F. The penetration test shows the consistency or degree of softness of an asphalt. A comparison of the penetrations at 32°F., 77°F. and 115°F. shows the relative susceptibility of the asphalt to changes in temperature. The susceptibility ratio indicates how thick a mopping may be applied and retained in place under ordinary application conditions The less the susceptibility, the thicker the mopping.

Ductility at 77°F. and 40°F. The ductility test indicates the relative adhesiveness and fluidity of asphalts. Generally speaking, the more ductile the asphalt the more adhesive and fluid it is. The word "fluid" is not used here in its ordinary sense, but is intended to express the slow movement or flow that some asphalts exhibit when to all appearances they are solids The asphalts which exhibit this property of flowing are in reality very viscous liquids, while those that do not flow are plastic solids. Ductile asphalts will not crack on contraction. It is the fluidity of an asphalt that renders it self-healing when punctured or ruptured.

Ascertaining the ductility of an asphalt at two different temperatures shows what effect change in temperature has on the particular physical properties disclosed by this test.

This test differentiates between the highly oxidised asphalts and those manufactured by straight run or by slight oxidation. The more oxidised the asphalt made from a given oil, the lower its ductility. Asphalts too highly oxidised are unstable.

Softening Point (Ring & Ball Method). This test shows the temperature at which the asphalt reaches a certain degree of softness, and, in connection with the penetration test, serves to measure its consistency.

Weight Loss on Heating for 5 hours at 325°F.
Loss in Penetration occasioned by this Heating; and
Ductility of the material after being heated at 325°F. for 5 hours.

This test is an accelerated exposure test. The less an asphalt loses, and, at the same time, the less it changes in both penetration and ductility, the longer it will retain its original physical properties.

Very truly yours,
DOW & SMITH
A. W. Dow.

AWD/MN

The following table will show that a not inconsiderable fraction of the engineering profession has practically standardized on a single type of waterproofing material. One after another, other types have been discarded as having proved unsatisfactory, one alone surviving the ordeal of time and effective service.

	ASPHALT SPECIFICATIONS									CLOTH SPECIFICATIONS			Date	Engineer or Architect
	Penetration			Ductility		Sol. in CS_2	Durability		M P	Count	Strength			
	32°F.	77°F.	115°F.	40°F.	77°F.		Loss in Wt.	Pen. Loss	R & B		Warp	Woof		
Bridge, Lawrence, Mass.	10 15	30 Max.	100 Max.		10 Min.	95			170 185		55	55	1914	B. H. Davis, N. Y.
Penna.-Detroit R. R.	10 15	30 Max.	100 Max.		10 Min.		½%		170 185		55	62	1916	B. V. Sommerville
Bridges, Columbus, O.	10 15	30 Max.	100 Max.		10 Min.						55	62	1917	City of Columbus
P. R. R. Lines, West	10 Min.	25 30	100 Max.	3 Min.	10 Min.	95	1%		159 175		55	62	1917	W. L. R. Haines
C. B. & Q. R. R.	10 Min.	25 35	100 Max.		10 Min.		½%				55	55	1918	G. A. Haggander
Bridge, Main St., Elmira, N. Y.	10 Min.		100 Max.		10 Min.	98	1%	20			55	55	1919	B. H. Davis
Hill-to-Hill Bridge, Bethlehem, Pa.	11 Min.		100 Max.		9 Min.	98			160 190		55	55	1919	Clarence W. Hudson
Bridge, Scranton, Pa.	10 Min.		100 Max.		9 Min.	99	1%	20%	150 180		55	55	1920	A. Burton Cohen
Power Plant, United Elec. Lt. & Power Co.	10 Min.		100 Max.		10 Min.	98	1%		150 180	18x26	55	55	1920	Thos. E. Murray, Inc.
Bridge, Trenton, N. J.	10 Min.		100 Max.	4 Min.	12 Min.	99	½%	20%	150 180	26x26	60	60	1921	J. A. L. Waddell & Son
D. L. & W. R. R.	10 Min.		100 Max.	4 Min.	12 Min.	99	½%	20%	150 180	26x26	60	60	1921	Geo. J. Ray, Chief Engr.
Bridge, Troy-Cohoes, N. Y.	10 Min.		100 Max.		15 Min.	99	1%	20%	150 170		55	55	1921	State of New York
Roof & Waterproofing N. Y. Co. Court House	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	Guy Lowell, Arch.
Chicago Union Station	10 Min.		90 Max.		20 Min.	95	1%		150 180	26x26	50	50	1922	J. D'Esposito, Chf. Eng.
Cedar St. Bridge, St. Paul, Minn.	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	M. S. Grytbok, City Eng. Bdgs.
N. Y. C. R. R., East	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	H. T. Welty, Eng. Struct.
Military Ave. Bdge., Detroit, Mich.	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	C. W. Hubbell, City Eng. J. W. Reid, Eng. Grade Sep.
Subways—City of Rochester, N. Y.	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	City Dept. of Eng.
C. & N. W. R. R.	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	J. S. Pole, Eng. Trk. Eleva.
Tent. Spec. Com. S2, Amer. Conc. Inst.	11 Min.		100 Max.	3 Min.	15 Min.	98	1%	25%		No m	embra	ne sp'd	1922	Committee S-2, Amer Concrete Institute
Lincoln Memorial, Pool-Washington, D. C.	10 Min.		100 Max.	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	55	55	1922	War Dept., U. S. Govt.
Power-House, Brooklyn Edison Co.	10 Min.		100 Max.	3 Min.	30 Min.	99½	½%	10%	150 170	18x26	50	50	1922	E. L. Knight, Chf. Eng.
School for Deaf, Trenton, N. J.	10 Min.		100 Max.	3 Min.	25 Min.	99½	½%	10%	150 170	18x26	50	50	1922	Guilbert & Betelle, Arch.
State Capitol, Lincoln, Neb.	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	Bertram G. Goodhue, Arch.
Reservoir, Asheville, N. C.	10 Min.		100 Max.		20 Min.	99	½%		150 170	20	50	50	1922	R. J. Sherrill, Com. Pub. Wks.
W. 73rd St. Bdge., Cleveland, Ohio	10 Min.		75 100	3 Min.	20 Min.	98	3%	25%	140 180	18x18 26x26	50	50	1922	F. R. Lander, Cc. Eng.
N. Y. C. R. R., West	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	60	60	1922	B. R. Leffler, Eng. Struct.
High School, Danville, Ill.	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	Lewis & Dougherty, Arch. W. H. Warner, Eng.
Fair Building, Chicago, Ill.	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	Mundie & Jensen, Arch.
Bridge, Shadesville, Ohio	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	Braun, Fleming, Knollman & Prior, Engrs.
Passaic River Bridge	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 170	18x26	50	50	1922	J. L. Vogel, Bdge. Eng. Dept of Highways, State of N. J.
Union Elec. Lt. & Pwr. Co., St. Louis-Cahokia Sta.	10 Min.		75 100	3 Min.	20 Min.	99½	1%	25%	150 170	18x26	50	50	1922	McClellan & Junkersfeld, Engrs.
Olden Ave. Bdge., Mercer Co., N. J.	10 Min.		75 100	3 Min.	20 Min.	99	½%	20%	150 180	18x26	60	60	1922	J. A. L. Waddell & Son
B. & O. R. R.	10 Min.		100 Max.	3 Min.	22 Min.	99½	½%	10%	150 170	18x32	50	50	1922	P. G. Lang, Jr., Eng. Bdgs.
P. & R. Rwy.	10 Min.		75 100	3 Min.	15 Min.	99½	1%	35%	150 170	35x35	70	70	1922	S. T. Wagner, Chf. Eng.
Karnak	10 Min.		75 100	3 Min.	10 Min.	98	1%	10%	150 180	18 26	50	50	1921	Gardiner & Lewis, Inc.
Karnak	10 Min.		75 100	3 Min.	20 Min.	99½	½%	10%	150 180	18 26	50	50	1922	Gardiner & Lewis, Inc.
*Karnak	12 Min.		75 100	4 Min.	35 Min.	99½	½%	10%	150 160	18 26	50	50	1923	Gardiner & Lewis, Inc.

*These three specifications written in successive years show the consistent improvement we are effecting in materials of this class.

STANDARDS ADOPTED

While it is clearly established that the standard tests will predetermine the quality of a bituminous material, it is of course obvious that the quality demanded will depend entirely on the particular set of constants that are placed after the test requirements. Having suggested in our specification a definite set of constants, the burden of proof rests with us to show why this particular specification may be assumed to give a product of higher quality than any other that might be chosen.

It must be admitted that practically all of our standards of material find their origin in actual field experience. This experience leads to the gradual elimination of certain types of material for a specific purpose, and as experience widens and results with various types are collected and coordinated, we finally reach the point in our development where a single type is chosen. This type on which the engineering world thus concentrates becomes a standard. We are not referring of course to a single trade name material or to the material of a single manufacturer. There is no monopoly of any type in the waterproofing field.

INTERPRETATION OF TESTS

To make this table intelligible, an understanding of the more important asphalt tests is necessary.

The penetration at 32° F., at 77° and at 115°. These show the depth (measured in hundredths of a centimeter) to which a weighted needle acting for a given time will penetrate the material. This test is therefore a measure of the consistency of the material, that is its relative hardness or softness, at the temperatures mentioned.

Ductility at 77° F. This measures the stretch of the material, or to put it another way, the elongation corresponding to a 100 per cent reduction in area of cross section. The ductility of an asphalt is the best gauge if not indeed the only gauge of the adhesion of the material to masonry, and in the particular type of asphalt called for in these specifications is likewise a direct gauge of the life of the material. This type of asphalt can be made only by what is known as the "blowing" or oxidizing process. This process properly conducted can and does produce a most efficient material. At the same time it is a dangerous one because of the possibility of over-oxidizing the material. The ductility is a positive check against this danger as it is impossible to over-oxidize an asphalt and keep the ductility high. Finally the ductility measures the ability of the material to heal itself if fractured. For every reason therefore this quality should be a maximum consistent with the other requirements.

Durability test. This test is made by heating the material at 325° F. for 5 hours and measuring the percentage of loss in weight and the percentage of hardening. This is an accelerated service test; the greater the loss in weight and the percentage of hardening, the less serviceable the material will be.

The percentage of the material soluble in cold carbon disulphide. This shows the purity of the product and, as the bitumen content alone has waterproofing value, the amount of the waterproofing agent in the material.

All of these tests should be applied. They form a composite whole and the omission of any one of them would make it impossible to draw definite conclusions based on the other four.

GENERAL CHARACTER OF TABLE

Attention is invited to the fact that the specifications analyzed in this table extend over a wide field both as to character of work and as to territory.

Flat slab work is seen in the case of the Nebraska State Capitol under plans of Mr. Bertram G. Goodhue; of the New York County Court House under plans of Mr. Guy Lowell, and in the several bridges mentioned.

Heavy foundation waterproofing appears in the Cahokia Station of the Union Electric Light and Power Co., of St. Louis, where the level of the floor is practically the level of the bottom of the Mississippi River—a direct head of 50 feet—and in the waterproofing of the United Electric Light and Power Company's Station in New York.

Reservoir work appears in the specifications for the waterproofing of the Lincoln Memorial Pool in Washington, D. C., as well as the reservoir in Asheville, N. C. In connection with the Lincoln Memorial Pool it may be said that the specifications for this work had the specific endorsement and the approval of the United States Bureau of Standards.

It is further to be noticed in this table that the quality of asphalt materials has very greatly improved since 1920 after a long period of stagnation in the waterproofing industry. This will be readily seen in a comparison of the specifications that were written previous to 1920 and those that have been written since. For this we frankly claim credit,

as all of this improvement is due solely and alone to our own investigations, research and experiments.

ESSENTIAL PROPERTIES OF ASPHALT

The value of the type of asphalt suggested in our specifications and shown in the table on page 8 becomes evident at once through analyzing the properties or characteristics a desirable waterproofing asphalt should have. These are:

1. It should offer the maximum possibility of permanence.
2. It should have a high ductility (a) because ductility is the only gauge to adhesion and the asphalt should adhere firmly both to the membrane and to the masonry; (b) because ductility is the measure of an asphalt to heal itself in case of fracture; (c) because in certain types of asphalt, i. e., the blown asphalts, it gauges the life of the material.
3. It should not be so soft that it will run from a vertical wall in summer temperatures, nor so hard that, when placed below ground, it cannot yield without fracture at 40 degrees F.

   In terms of standard asphalt tests, the consistency of the material as measured by the penetrations (see page 9) should be relatively high at 32 degrees and relatively low at 115 degrees.
4. It should retain a high viscosity at application temperature (325 to 375 degrees F.) so that a heavy coating can be applied. This again demands a low penetration at 115 degrees F.

These are self evident and need no argument or supporting data. The only question is to what extent if any these properties may be found in asphalts of a different type from that which has been suggested.

This involves a discussion of the three important classes or groups of asphalts which are marketed for waterproofing purposes. These are (a) asphalts derived from asphaltic petroleums, or refined asphalts; (b) Fluxed asphalts; (c) the Lake asphalts.

UNFLUXED REFINED ASPHALTS

This group comprises those asphalts which have been refined from liquid bases, viz: the so-called malthas or the heavy liquid petroleums. This group is divided into two classes, based on the method of refining used. These classes are "straight refined" asphalts and "blown" asphalts. The former are the result of refining by direct heat. The latter are produced by forcing air through the liquid material under pressure. These two classes have distinctive physical properties by which each may be recognized. The "straight refined" asphalts are characterized by a wide susceptibility to temperature change—being relatively hard at 32 degrees F and soft at 115 degrees F. They entirely lack the property of toughness and are exceedingly fluid at the application temperature.

The blown asphalts are tough and rubbery, have little susceptibility to temperature changes and are very viscous at application temperature. In these particulars then they meet the requirements of good waterproofing.

Table showing comparative properties of straight refined asphalt and a properly blown asphalt.

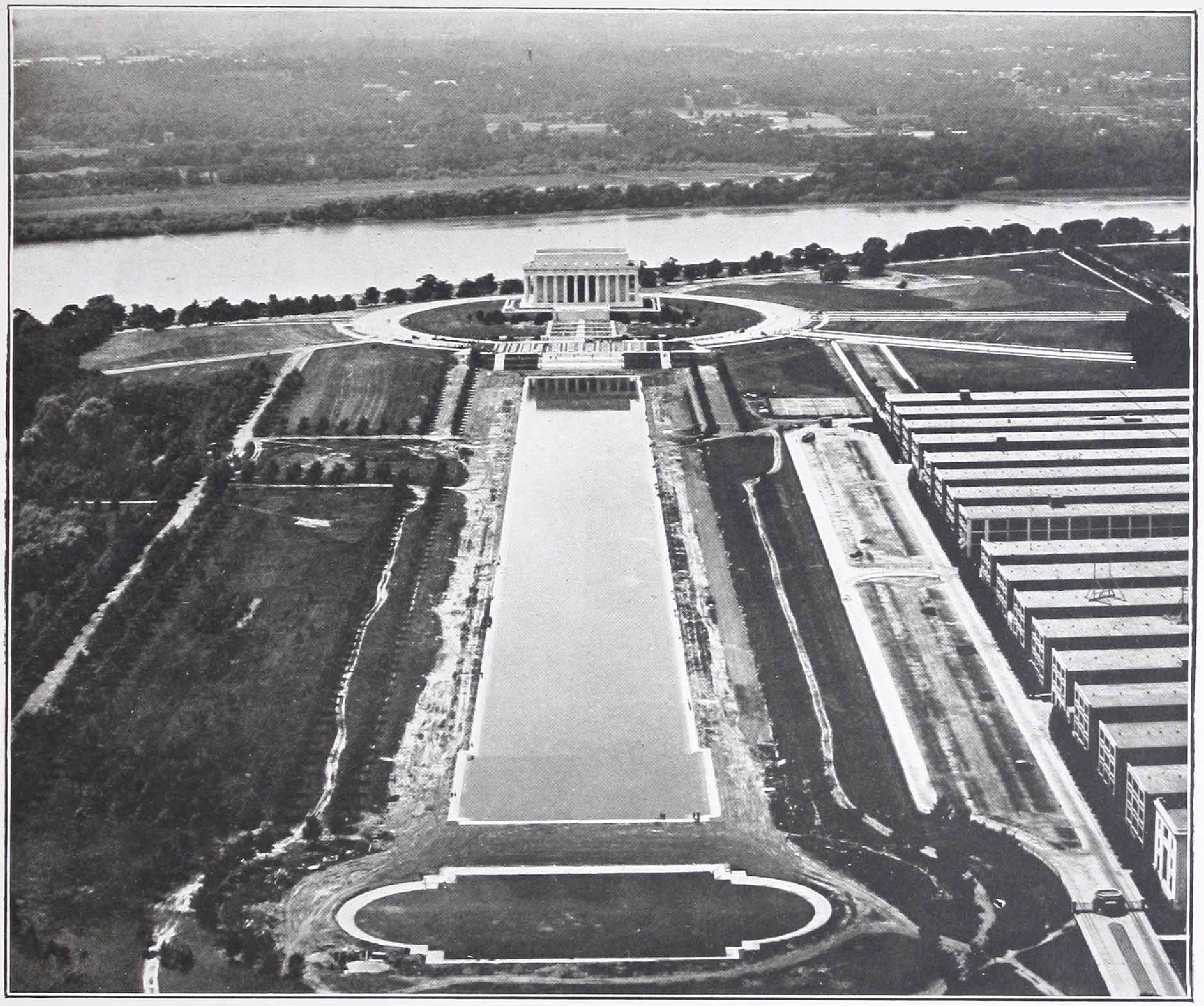
	Melting Point, F°	Penetration at 32°	77°	115°	Ductility at 77°
Straight Refined	150	15	45	180	80
Blown (Karnak)	158	14	28	98	50

From this table the extreme softness of the "straight refined" asphalts at 115 degrees F. is apparent, illustrating the undesirable properties to which attention has been called. Quite the reverse property is illustrated in the "blown" asphalt.

Blown asphalts however must be regarded with a certain caution. Properly refined, they are certainly the most effective and permanent of waterproofing materials. But it is very easy to ruin them in the refining process. This can be readily understood if it is appreciated that "blowing" an asphalt is an oxidizing process, and as in all cases of artificial or forced oxidation there is an ever present danger of overoxidation, of forcing into the asphalt more oxygen that it can absorb. If this is done the asphalt will lose its cohesion, will become "cheesey" as it ages and will soon disintegrate.

Fortunately however we have a positive check against an overoxidized asphalt in the standard tests. As an invariable result of blowing is a reduction of the ductility measurement in direct proportion to the extent of oxidation, it follows that such a check would be found in the ductility. No blown asphalt should be used which has a ductility of less than 20 c.m. at 77 degrees F. and for reasons which have already been emphasized it should be as high as possible.

As is indicated in the tabulated specifications on page 8 the tendency of those specification writers who have made the closest study of waterproofing materials, is to keep raising the ductility requirement



REFLECTING POOL BETWEEN THE LINCOLN MEMORIAL AND WASHINGTON MONUMENT, SOUTH POTOMAC PARK, WASHINGTON, D. C.

Constructed under the direction of the War Department, Corps of Engineers, Office of Public Buildings and Grounds.

The entire bottom and sides of this pool, involving an area of about 9 acres, are waterproofed with 2-ply KARNAK FABRIC and KARNAK ASPHALT. Approximately 135,000 yards of Fabric and 70,000 gallons of Asphalt were required.

within the fixed penetration limits. It is in this direction that the greatest improvements in asphalt refining have been made.

There is every evidence that a properly blown or properly oxidized asphalt is the most permanent form of bituminous material. We need no further proof of it than the well known fact that the most common and most permanent form in which most materials are found in nature is as an oxide. Nearly all elements are found as oxides; and if minerals be exposed to the action of natural forces in most cases they will be turned into oxides. Iron is the most familiar example. Iron rust is but iron oxide and as we know from its extensive use as a paint pigment, it is permanent. There is no conceivable reason why the same general principle should not apply to asphalt.

FLUXED ASPHALTS

Fluxed asphalts are compounds or mixtures made by adding either a soft asphalt or an oil to a hard asphalt to reduce it to a proper consistency. The use of such a material, whether compounded with the hard asphalts of the Gilsonite class, or with refined semi-solids such as the Trinidad or Bermudez, is always attended with danger, as it is extremely difficult to determine, even by chemical examination, whether the combination between the flux and the hard asphalt is a permanent one. Some fluxes will combine with a particular base and give lasting results; some will not. Where the flux is not suitable, the compound deteriorates rapidly and becomes "cheesey", free oil is liberated and is absorbed by the concrete or evaporates, leaving behind, eventually, a hard, brittle asphalt. A fluxed asphalt therefore while not necessarily faulty is at least always open to suspicion as to its permanence.

Since asphalts of this class are synthetic mixtures it is practically impossible, in any given case, to forecast whether the material will or will not give satisfactory service. The only valuable test is the test of time and even this involves the practical impossibility of determining whether the fluxed material subsequently offered is the identical flux on which the test was made.

The standardized asphalt tests will almost invariably detect a fluxed asphalt. For the same ductility it will be much softer at 115 degrees F. than the refined asphalts; while under the standard heat test the percentage of hardening as shown by the relative penetrations at 77 degrees before and after heating will be much greater.

LAKE ASPHALTS

This term is used to describe those asphalts which are obtained from Bermudez and Trinidad Lakes.

Neither of these asphalts can be used in their crude state; both require to be refined by the application of heat under proper regulation. And it is an important fact that in this process approximately 33 per cent by weight of Trinidad and nearly 40 per cent of Bermudez, in the form of water and light oils is driven off the crude materials.

In both of these products, however, the change which has been effected by nature in the character of the original petroleum from which they are derived has progressed so far that the refining cannot vary the character of the final product materially without destroying or greatly injuring it. In their refined state, therefore, they are entirely too hard for waterproofing work (as evidenced by the analyses shown later) and have to be softened by the use of a flux or softening agent. This immediately brings then in the class of fluxed asphalts, which for reasons stated under that heading are at best of uncertain life and behavior.

It is claimed for these products that exposure to the tropical sun for years has produced a stable and unchangeable material. This is disproved by the following facts:

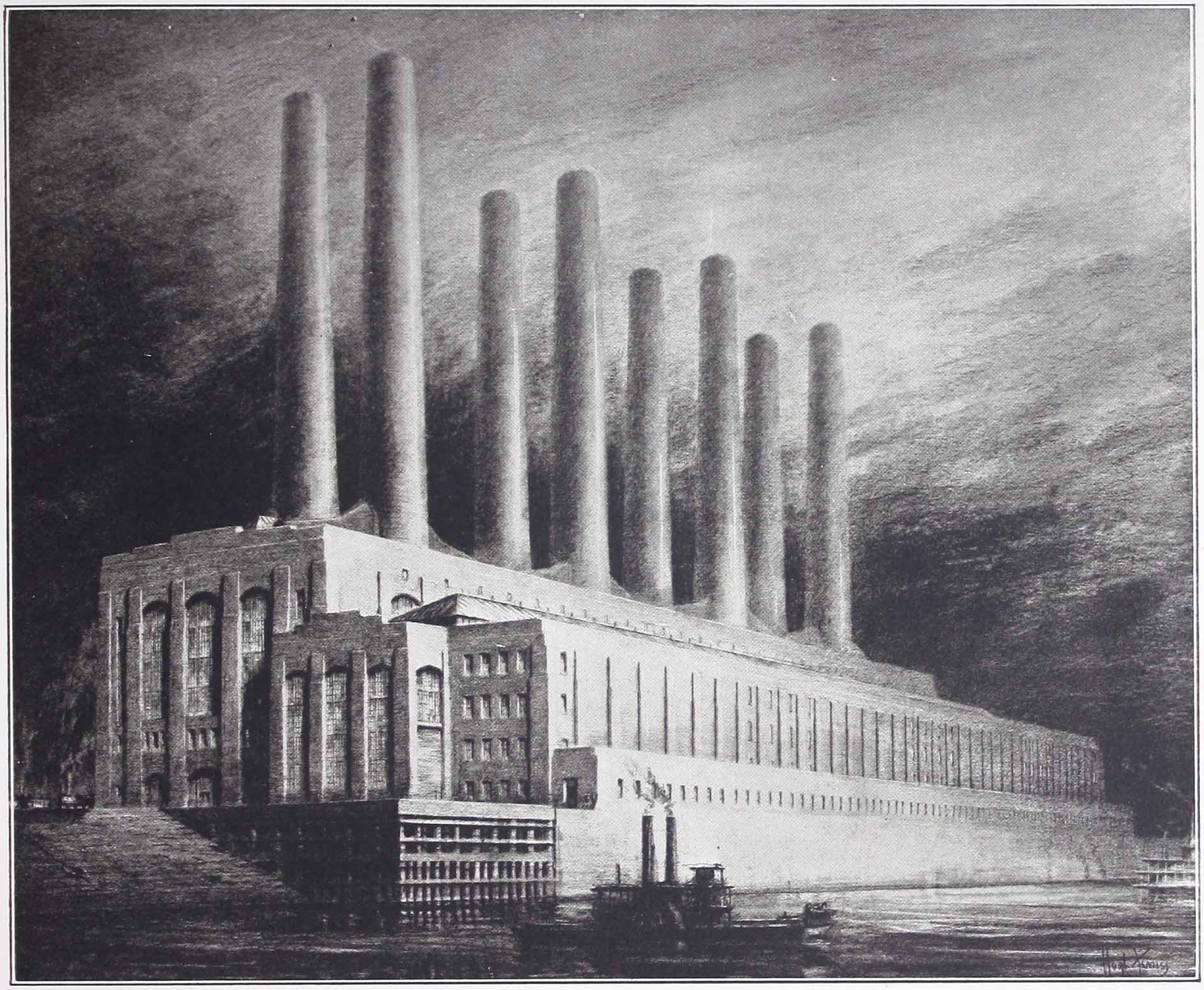
a. Water has a rapidly destructive effect on Trinidad asphalt.

b. There is a very appreciable quantity of light oils in both which have not been stabilized (4 per cent in Trinidad and 11 per cent in Bermudez).

c. Since the asphalt in Trinidad Lake is in constant movement, the time of exposure of any particular lot is small. As to Bermudez, everything would indicate that the Bermudez deposit is of recent origin and has not been exposed for ages to the tropical sun.

d. Under the heat (or durability) test (see page 9) their lack of stability is indicated by their hardening, Trinidad and Bermudez both hardening more than 30 per cent.

Even if true the claim as to unchangeability by reason of tropical exposure would not apply to the waterproofing asphalts made from lake asphalts because, as has been stated, they are always compounded with oils or softer asphalts from other sources to reduce them to a proper consistency; so that the stability of the base is not a gauge of the stability of the finished product.



CAHOKIA STATION, UNION ELECTRIC LIGHT & POWER COMPANY,
NEAR EAST ST. LOUIS, ILL.

McClellan & Junkersfeld, Inc.,
Engineers & Constructors.

Mauran, Russell, & Crowell,
Consulting Architects.

The first section, constructed in 1923, is waterproofed with KARNAK FABRIC and KARNAK ASPHALT. The waterproofing on this structure, which is directly on the Mississippi River, is subjected to pressures as high as 3000 pounds to the square foot. Approximately 1,250,000 square feet of fabric and 70,000 gallons of asphalt will be required for the completed structure.

This table shows a comparison of Trinidad and Bermudez, refined, asphalts with KARNAK asphalt.

	Penetration at 32° F.	Penetration at 77° F.	Penetration at 115° F.	Ductility at 77° F.	Durability % Loss in wt.	Durability % of hardening	% Soluble in CS_2
Trinidad	0	2	12	*	0.6	30	56
Bermudez	5	21	133	27 cm.	0.8	29	96
Karnak	14	28	98	50 cm.	.06	7	99.9

* Too brittle to test.

NOTE: The figures given in this table are the results of actual tests of these materials made by an independent laboratory. Notice in the durability test the rapid hardening under heat of these materials which have presumably been stabilized by nature.

Finally in the fluxed Lake Asphalts a tendency to disintegration becomes apparent on exposure directly to water. This is particularly marked in the Trinidad fluxes. Exposure to water will cause this material to swell to nearly twice its size and to disintegrate rapidly. It is entirely unsuitable to any form of structural waterproofing and should never be used except where it may be constantly kneaded, as by street traffic.

In addition to what has been said as to the Lake Asphalts it is evident from this table that Trinidad asphalt possesses none of the properties essential to a good waterproofing. It is entirely too hard at all temperatures, is completely lacking in ductility, contains but a small percentage of real waterproofing as evidenced by the bitumen content.

Bermudez asphalt is very hard at 32 degrees F., is too soft at 115 degrees F. and contains a high percentage of harmful organic matter.

PRACTICAL APPLICATION

While the foregoing is to some extent a theoretical discussion, the practical application of this theory finds its exposition in the table of specifications which appears on page 8. The experience of the engineering profession has been that better and more constant results have been obtained with the type of material shown than with any other on the American market.

ASPHALT OR COAL TAR PITCH

One question will occur immediately to many users of waterproofing materials who have read what has so far been presented. This question is:

1. Why use asphalt at all in preference to coal tar pitch which is cheaper and which has been in successful use for fifty years?

As to this question, it may be said that the use of asphalt literally antedates the Christian era. Samples have been found, still plastic, still full of life, that were placed 2500 years B. C. This merely indicates, however, that if a proper asphalt be selected, it will have an effective life many times greater than any known record of which coal tar pitch can boast. It is not advanced because of any demonstrable identity of the asphalt suggested with that of antiquity. Considering strictly modern materials, the most exhaustive research has not developed a single fact that would even indicate that a properly refined asphalt is less durable as a subsurface waterproofing than coal tar pitch. There are opinions on the subject of course; but opinions unsubstantiated by any facts or any reliable data. Certain asphalts do deteriorate rapidly in contact with water. The Lake Asphalts, for example (see page 12) do not stand up under water and should never be used for such service. But no conclusion can be drawn as to the behaviour of an individual member of a large class of materials based solely on observations of another individual member of that class.

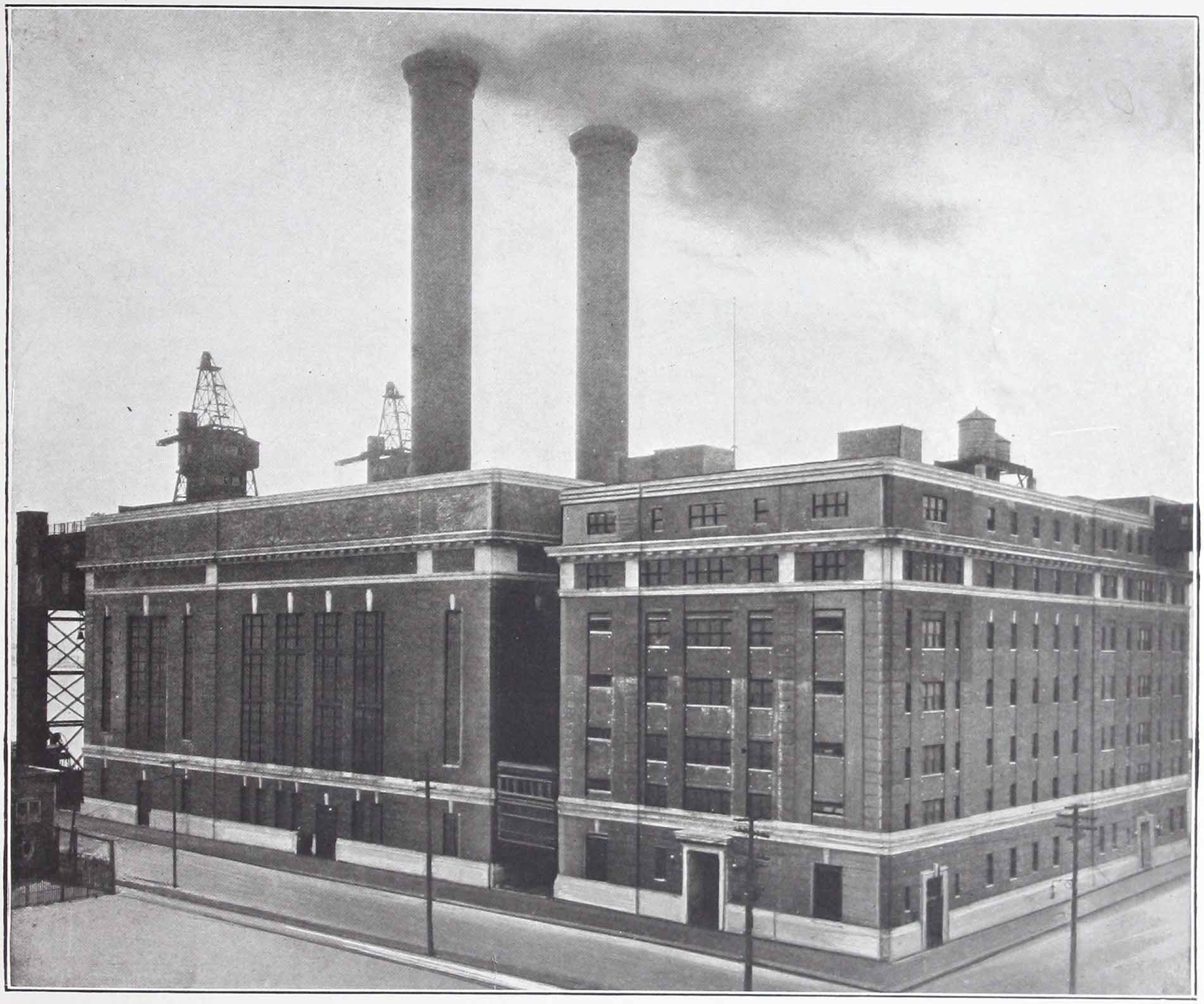
ADVANTAGES OF ASPHALT

The advantages that a proper asphalt possesses over pitch, are very definite and very positive. Some of these are:

The quality of the waterproofing asphalts offered to the consumer has been steadily raised during recent years, and the present high quality is capable of being maintained in large quantity production. In order to prove this improvement in quality it is only necessary to compare the first of the asphalts specified in the table on page 8 with the last. To this attention has already been invited.

DISADVANTAGES OF PITCH

The quality of present-day coal-tar pitch on the other hand is not equal to that of the pitch of fifty or even fifteen years ago. Modern pitch is not uniform, and the quality of any particular pitch is more difficult to determine than is the quality of a particular



POWER PLANT OF THE UNITED ELECTRIC LIGHT AND POWER COMPANY,
134TH STREET AND LOCUST AVENUE, NEW YORK CITY.

THOMAS E. MURRAY, INC., Engineers.

All foundation work of this structure, which is almost directly on the Bronx River, is waterproofed with KARNAK FABRIC and KARNAK ASPHALT.

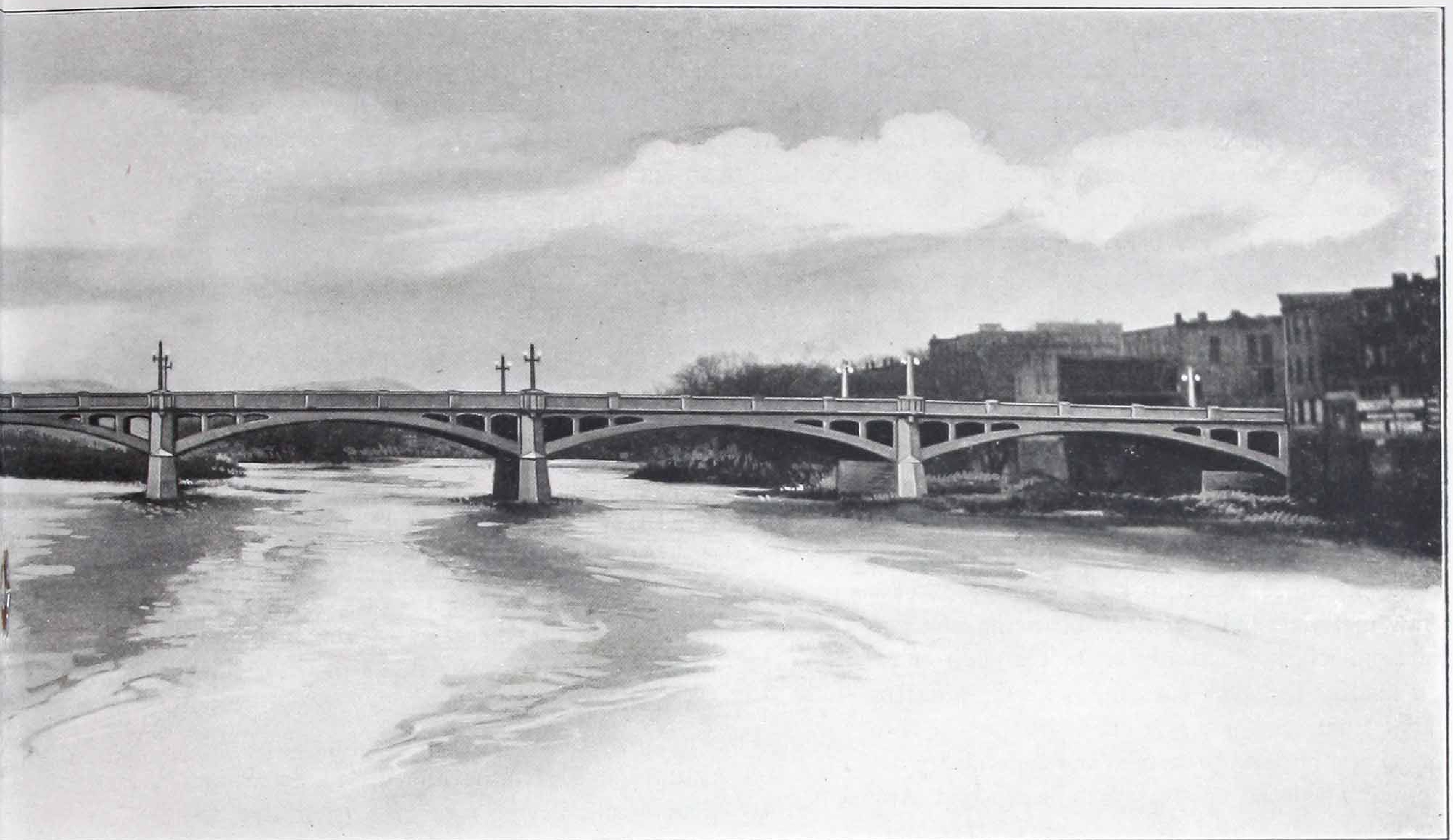
MAIN STREET B

B. H. DAVIS,
Consulting Engineer

Entire floor system waterproofed v

PORTION OF EAST END OF VIADUCT, EAST ORANGE STATION, D. L. & W. R.R.

These two viaducts and all others that we
and 1922 in connection with their New Je
FABRIC and KARNAK ASPHALT. The waterpi
MASTIC and all retaining walls were damp



IDGE, ELMIRA, N. Y.

ith KARNAK FABRIC and KARNAK ASPHALT.

T. L. EYRE,
General Contractor

PORTION OF WEST END OF VIADUCT, BRICK CHURCH STATION, D. L. & W. R.R.

constructed by the D. L. & W. R.R. during 1921
ey improvements were waterproofed with KARNAK
ofing was protected with 1½" of KARNAK ASPHALT
roofed with KARNAK TROWEL PLASTIC.

asphalt. Well known developments in the coal-tar industry conclusively prove this statement, which is not a matter of opinion but of historical fact. Until about fifteen years ago, practically all coal tar from which the pitch was derived, resulted from the destructive distillation of a very uniform bituminous coal, known as gas coal because it was the only grade of coal used in the manufacture of illuminating gas. The tar—all of which came from the gas houses—was likewise uniform; and from it the production of a uniform pitch was a simple matter. But about fifteen years ago the process of gas manufacture changed, or, more accurately, the change became general. Water gas was made—not coal gas—so that the source of raw material for coal tar pitch was cut off. Recourse was then had to the coke ovens for raw material, and coke oven tar is the raw material from which practically all of the pitch of today is made. But coke oven tar is a very different material from gas house tar. It is different in both chemical and physical properties and is decidedly not uniform. The latter of course is to be expected. Any bituminous coal is used in coke ovens. The only qualification is that it be near at hand and so carry a minimum freight charge. As bituminous coals vary greatly in the different fields, it follows that the tar from them likewise varies. Also it is inevitable that pitch made from a variable tar must vary to exactly the same extent that the raw material varies.

Every effort is made by the manufacturers of course, to produce a uniform material by fluxing different tars or different pitches until a uniform consistency is reached, and this fluxing is always done. But that makes the pitch a synthetic product and not "straight run" pitch at all. Moreover it has been found that while it is possible by fluxing methods to bring two pitches to the point of practical physical identity, they do not necessarily function alike in service. This is due, presumably, to the fact that it is impossible to determine in any form of bituminous material, asphalt as well as coal tar pitch, whether a particular flux is or is not chemically and physically stable, whether or not there is a thorough amalgamation of the parts; and although there is an asphalt test which will almost invariably detect a fluxed asphalt, there is no such test in the case of pitch.

It is also a well recognized fact that during the last fifteen years and particularly since 1914, the science of coal tar by-product extraction has advanced with great rapidity. Many by-products are extracted today which fifteen years ago we either did not know how to take out, or as they were then without commercial value there was no reason to take them out. It is claimed that this does not impair the quality of the jitch—that it is in fact improved. This may of course be true; equally of course it may not. The question is, of what value are service records of twenty or thirty years, when the material on which those records were based is no longer available?

The most pertinent facts then in regard to coal tar pitch are these:

1. We are dealing with a relatively new material that certainly does not go further back than ten years.
2. The modern pitch is apt to vary greatly depending on the character of raw material, with corresponding variations in the results obtained.
3. The quality and serviceability of any particular pitch is more difficult to determine than would be the case of a particular asphalt.

WATERPROOFING CONTENT IN PITCH

Supplementing these facts about coal tar pitch, there are certain physical properties that should be noted. It contains a very large percentage of volatile matter—the maximum limit appearing in most specifications being 14 per cent—and the greater part of this volatile content is driven off in the process of heating it in a tar kettle.

The true waterproofing agent—that is the bituminous content—is relatively small, being but about 75 per cent. The remaining 25 per cent which is free carbon or lamp black, functions only as a mechanical filler to stiffen the material and so raise the flow point. Its specific gravity is about 25 per cent greater than that of a good asphalt.

If therefore, we analyze both materials to determine the units of volume of bituminous material (and it is volume and not weight that functions in a waterproofing blanket) in a given weight, correcting for the difference in specific gravity and allowing 10 per cent for volatilization, we find that we would have 100 such units in asphalt and but 45 in coal tar pitch. This would mean that it would require two and a quarter times as much coal tar pitch as asphalt by weight to accomplish the same results.

This is illustrated graphically in the drawing shown on the following page.

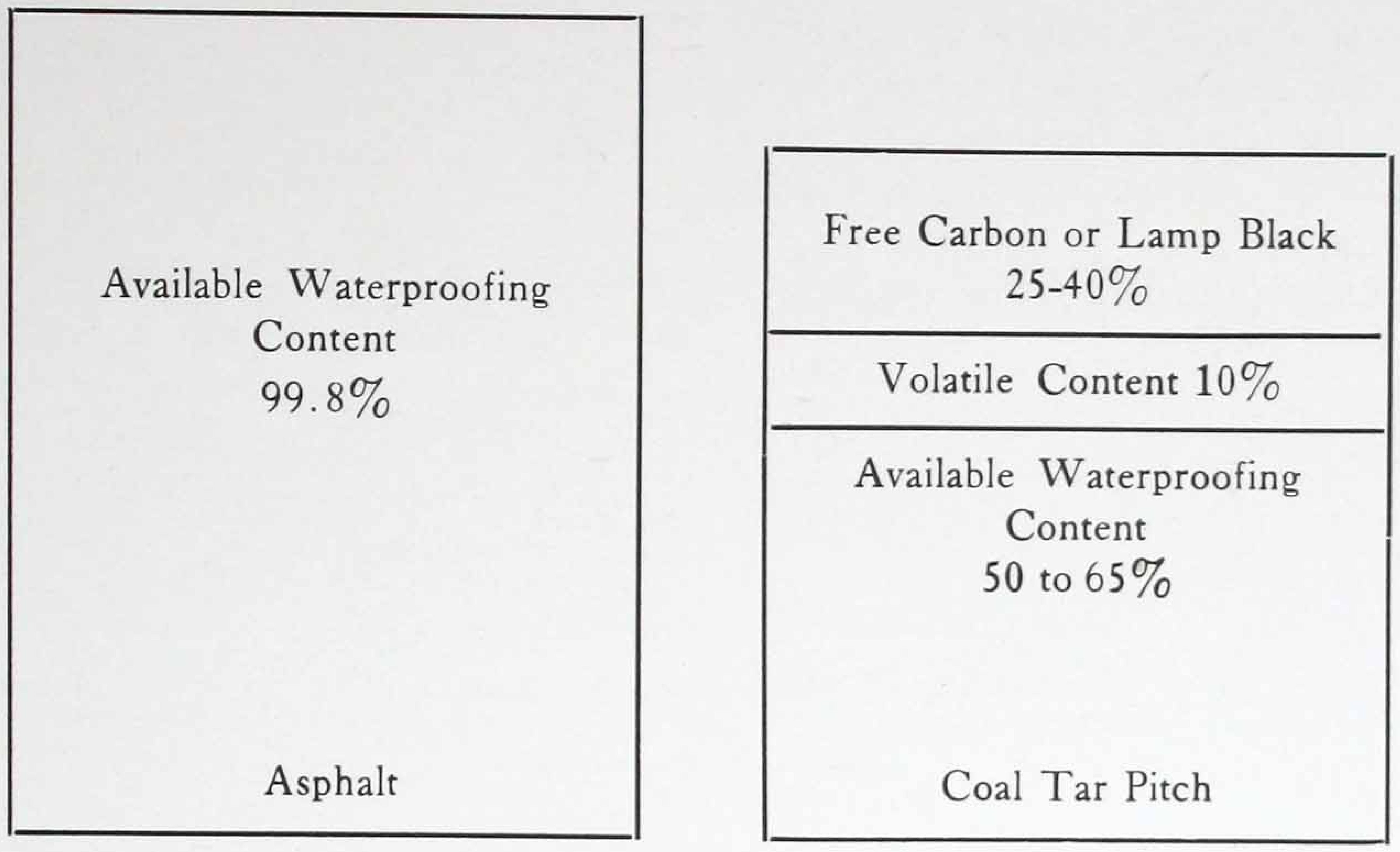


Diagram showing relative volume of available waterproofing content in the same weight of asphalt and of coal tar pitch.

THE MEMBRANE

The function of the membrane in a waterproofing blanket is not, as is often supposed, to make possible the piling up of a thick mass of the waterproofing agent. If it were, cheap building paper would serve as well as the more expensive materials. Nor is it used for any waterproofing value it might have in itself as no membrane has any such value. Its function is precisely the same as that of expanded metal in concrete, i. e., to hold the surrounding material in place, to prevent it from cracking up.

The selection of the proper type of membrane can be made only as a result of an engineering determination of the structural conditions to which the material is to be subjected in service, and of the stresses these conditions create in the blanket.

I Of primary importance, of course, is the requisite that the membrane be unaffected by water. Even though the membrane exists only as a binder with no waterproofing value *per se,* it is elemental that the membrane should be permanent under service conditions, and that it should remain effective even though water may reach it directly. To be compelled to waterproof the waterproofing is to approach the ridiculous.

II The membrane should be elastic. Cracks may develop, due to settling, internal stresses in the concrete, opening of construction joints. The waterproofing course should be able to stretch sufficiently to meet these conditions without fracture.

III The membrane should have a certain measure of strength. A good waterproofing bitumen has a very positive adhesion to any form of masonry base. It also naturally adheres strongly to the membrane. If any increase in the waterproofed area occurs, by the formation of cracks or otherwise, stresses are created in the entire blanket; and if these stresses are localized, the blanket will rupture. The membrane therefore must be strong enough to distribute these stresses through the bitumen, a material distance on either side of the crack and thus prevent this localization. In this way the stretch in a considerable length of the membrane will be brought into play. This may be briefly though inexactly expressed by stating that the strength of the membrane must be greater than that of the bitumen.

IV The membrane should have an open mesh or (to put it another way) should be sufficiently porous to allow for free penetration of the waterproofing material proper, i. e., the asphalt or the coal tar pitch. The function of the membrane, it must be remembered, is to reinforce the waterproofing—to hold it in place and prevent it from breaking or cracking. In this particular its use is entirely analogous to the use of expanded metal in a concrete plate. Therefore, just as the mesh of the metal permits the concrete to pass through and interlock with itself, so should the waterproofing pass through the membrane.

Again, if we specify a given thickness of material, as we do when we require a given number of pounds or gallons to be used in waterproofing a given area, we want the waterproofing value of that thickness

as a whole, not the value of a number of thin films that aggregate that thickness. It we create these films by dividing the required thickness with layers of a material that the waterproofing does not penetrate, the resulting efficiency is measured by the efficiency of each individual film and not by the total thickness at all.

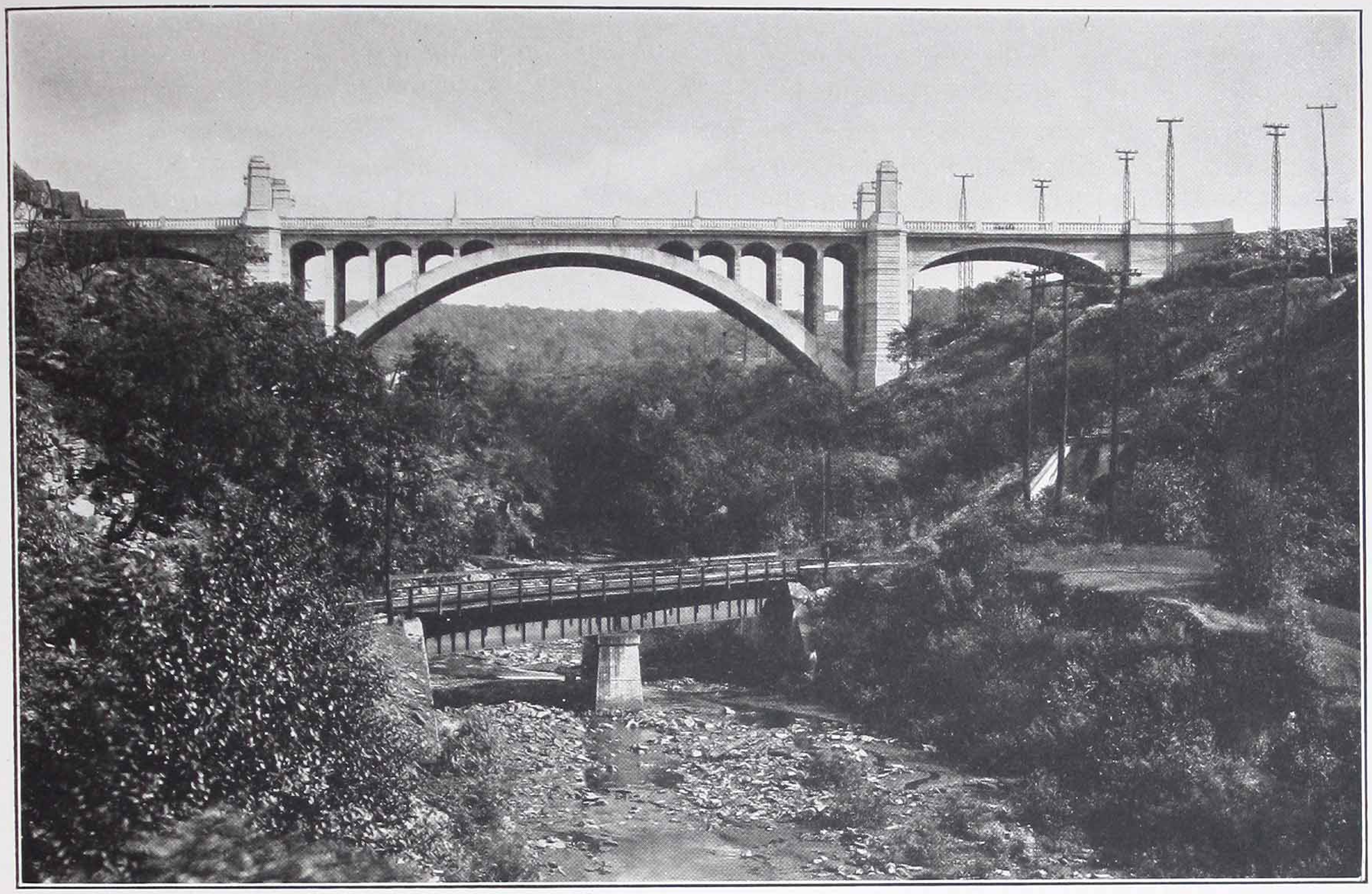
V The waterproofing blanket should conform closely to the surface to which it is applied, following strictly all surface irregularities and fitting snugly into all corners where it changes direction. In other words it should have solid backing everywhere with a complete absence of unsupported spans or "bridges" which will break down if subjected to traffic.

VI The treated membrane should be without capillary properties and should facilitate such an intimate welding of the successive moppings that lateral translation of water through the blanket is impossible. The importance of this lies in the fact that water often rises over the footings before the wall and floor courses are applied. It is necessary that the footing course remain intact so that a secure junction can be made between it and the floor and wall courses.

The following table presents an analysis of the various membranes on the market.

Type of Membrane	*Composition*	*Effect of Water on*	*Elastic Properties*	*Tensile Strength*	*Flexibility*	*Capillarity*
Asbestos Felt...... (Saturated)	Asbestos fibre tied together with tapioca or starch and run through a bath of liquefied asphalt and resin.	The fibre itself will be unaffected; but the felt is liable to disintegrate because both starch and tapioca are soluble in water.	None	Weakest of all felts.	Rather brittle. Liable to break if bent over sharp corner.	None
Rag Felts........... (Saturated)	Composed of Cotton rags and wood pulp. First treated with creosote to prevent dry rot, then put through a bath of liquefied asphalt or coal tar pitch.	When immersed softens very materially and gradually melts.	None	Very weak but somewhat stronger than asbestos felt.	Same as asbestos felt.	Have very appreciable capillary properties.
Burlap or Jute.. (Saturated)	A harsh woody fibre impossible to impregnate completely with a viscous material. Is first treated with thin asphalt or coal tar cut back, and then coated with asphalt or coal tar.	Rapidly destroyed particularly if water carries alkali—very unstable chemically. Will be rotted even by moisture in the air.	Practically none.	Considerable when fresh but quickly dissipates with age.	Flexible when new but becomes brittle with age.	Very highly capillary and hygroscopic. These properties but little decreased by saturating treatment.
Cotton Cloth...... (Saturated)	A pure cellulose chemically stable. Can be thoroughly impregnated with asphalt without the aid of solvents.	Entirely unaffected by water if completely saturated.	Excellent if proper base fabric is selected.	Any strength desired.	Extremely flexible at all temperatures. Does not deteriorate with age.	Absolutely without capillary properties and non-hygroscopic.

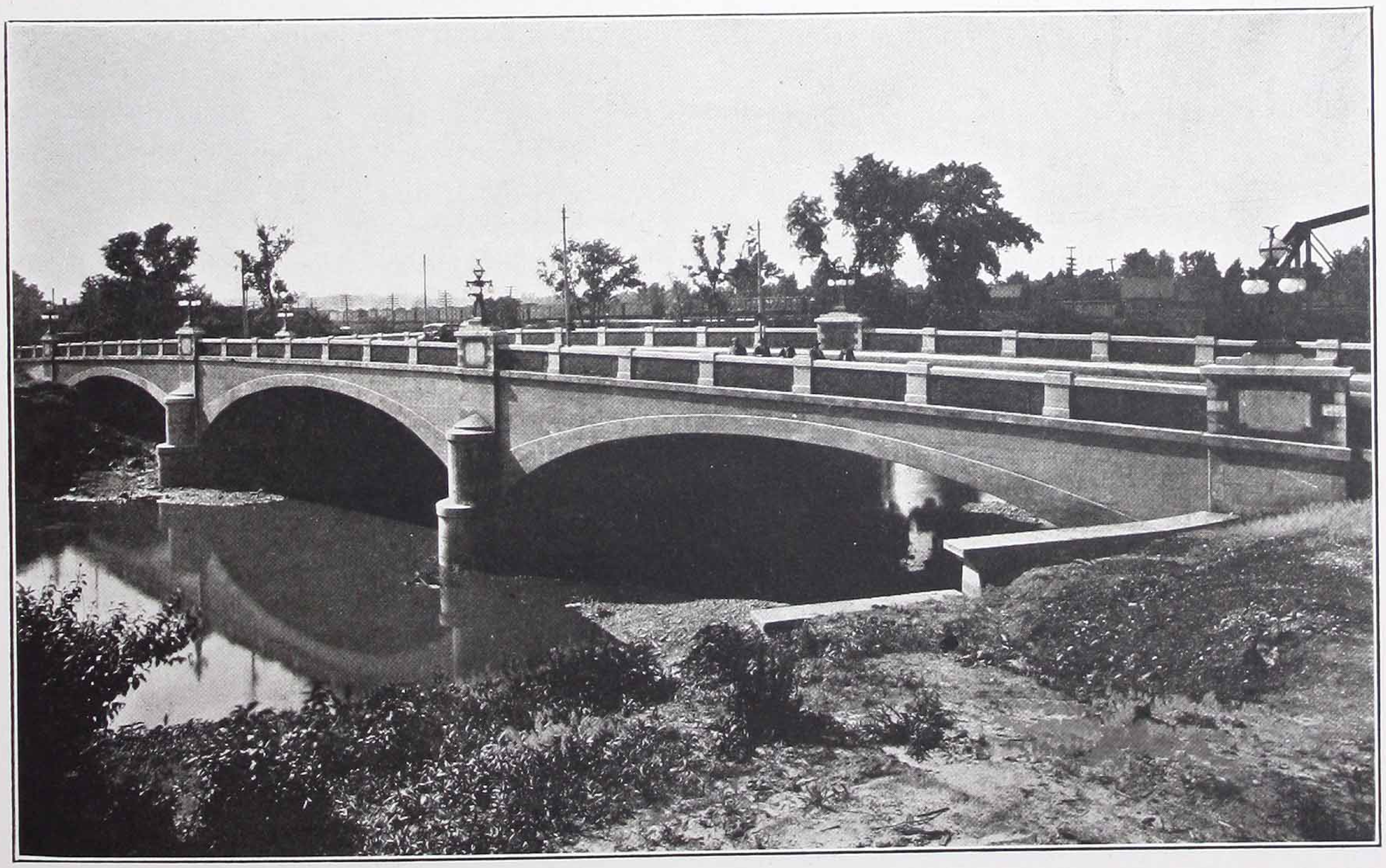
A brief examination of this table will show that of all the membranes, a properly saturated cotton fabric alone fills the structural requirements. Nor is this mere theory. The experience of the past ten years has demonstrated conclusively that the theory is not only sound but is entirely correct in practice.



SOUTH-TO-EAST SCRANTON BRIDGE, SCRANTON, PA.

A. B. Cohen,
Consulting Engineer.

Anthracite Bridge Company,
General Contractors.



BRIDGE AT FT. WAYNE, IND.

Braun, Fleming, Knollman & Prior,
Consulting Engineers.

A. W. Grosvenor,
Engineer.

Both structures waterproofed with KARNAK WATERPROOFING.

Ten years ago, all of the consulting engineers and all of the railroads, used as a membrane in their waterproofing five or more plies of either rag or asbestos felt. Gradually this method has been given up—one by one they have substituted two plies of cotton cloth for the multiple plies of the weaker felt until today the great majority of engineers are using a cloth system. Their experience has demonstrated beyond question that two cardinal principles underlie all successful waterproofing, viz:

1. If a film of material is truly waterproof it cannot be made more so by piling up additional films. The results are a function of the quality of material and the perfection of its application rather than of its mass.
2. As a corollary of the first, results depend on a high quality material held in place by a strong, elastic binder, which binder is itself guarded by a film of the same material above and below it.

KARNAK MATERIALS

KARNAK ASPHALT

The production of a good waterproofing asphalt that will meet all of the requirements that have been laid down in the preceding discussion is not simple. Refining is conducted in large bricked-in stills that give very limited opportunity for manipulation of any sort while the asphalt is in process. There are, too, many variables that have to be controlled; the consistency of the crude material, the amount and intensity of the heat, the quantity of air that is forced into the material. The extent to which these variables are controlled measures the quality and the uniformity of the finished product. There are no secret formulae or secret processes used in refining asphalt—our own or any other. They are all made by well known and generally standardized methods. It is in the manipulation of these methods and in the control of the elements that enter into them that successful quality production lies and it is along these lines that all of our research and investigations have been conducted.

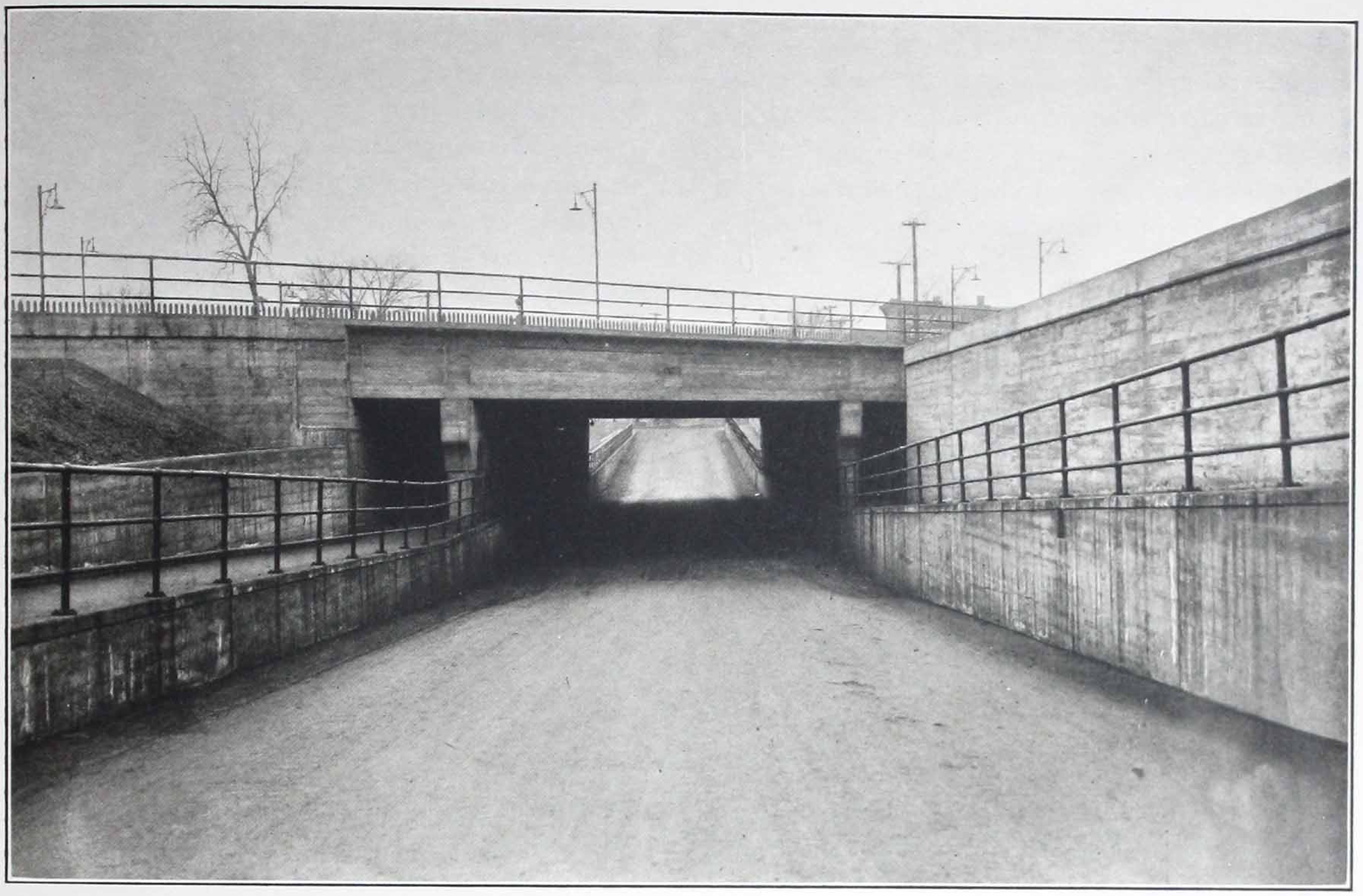
KARNAK Waterproofing Asphalt is the result of the most precise control of the different elements of refining, and the most careful engineering supervision of every stage in the refining process. We believe that in the production of Karnak this control is more exact and the supervision more accurate than is being exercised in the production of any other waterproofing material. If this is the case KARNAK Asphalt should represent in quality and uniformity, the highest point to which asphalt refining has yet been carried; and this superiority should make itself evident through the standard tests on which so much stress has been laid in the preceding pages. That is precisely how KARNAK quality becomes manifest. Such tests will show that, within the type of asphalt suggested in our specifications, which type by reason of its general and widespread use has practically become an engineering standard, KARNAK Asphalt possesses the required properties in a higher degree than any other asphalt on the American market.

That the consumer may be assured that he is getting true KARNAK quality, we have each individual refining tested by an independent laboratory, which laboratory affixes to each drum a label or seal bearing its name and the test number. The test corresponding to this number will always be furnished by the laboratory. Thus ready comparison can be made between the material furnished and the specification which KARNAK represents.

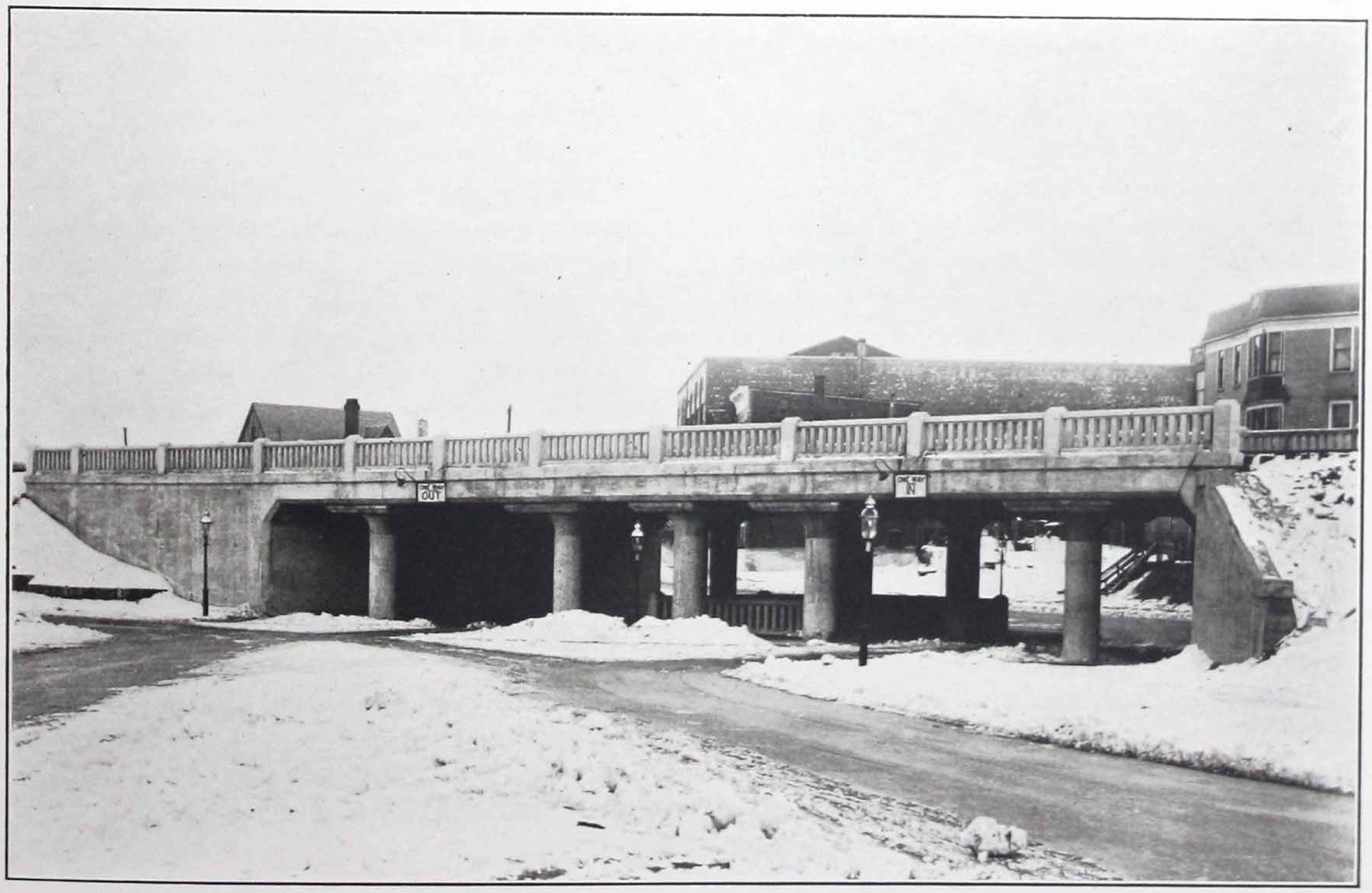
KARNAK WATERPROOFING FABRIC

No theory of waterproofing has been so quickly demonstrated nor so readily seized upon by the constructing profession as that of the open mesh saturated cotton membrane. That theory was first advanced by us in 1920 and its logic was so sound that in the three years that have followed, it has become, like the KARNAK type of asphalt, practically an engineering standard.

KARNAK Fabric is produced from an excellent grade of cotton cloth made of long staple cotton, free from the short ends or waste that are present in most grades of waterproofing fabric. The saturation is effected under accurate heat control to



CHICAGO & NORTHWESTERN RAILROAD BRIDGE AT CLINTON, IOWA.
Waterproofed with KARNAK FABRIC and KARNAK ASPHALT
All of the 1923 improvements of this Railroad will be waterproofed with KARNAK MATERIALS.



VIADUCT AT AMPERE, N. J. D. L. & W. R.R.
Waterproofed with KARNAK FABRIC and KARNAK ASPHALT.

prevent charring the cloth, and the entire production is conducted under the same character of supervision as marks our asphalt production. The result is a highly uniform fabric with perfect saturation, and with the meshes open and unclogged so that perfect amalgamation of the successive layers of asphalt occurs.

One roll out of every six that we manufacture is tested by an independent laboratory specializing in this class of work and every package that is shipped bears the laboratory's label and findings. Consequently, in using KARNAK materials the consumer is entirely protected as to quality and is assured by the most casual inspection of the material as delivered, that it has all been inspected and tested against his specifications.

SPECIFIC PROBLEMS

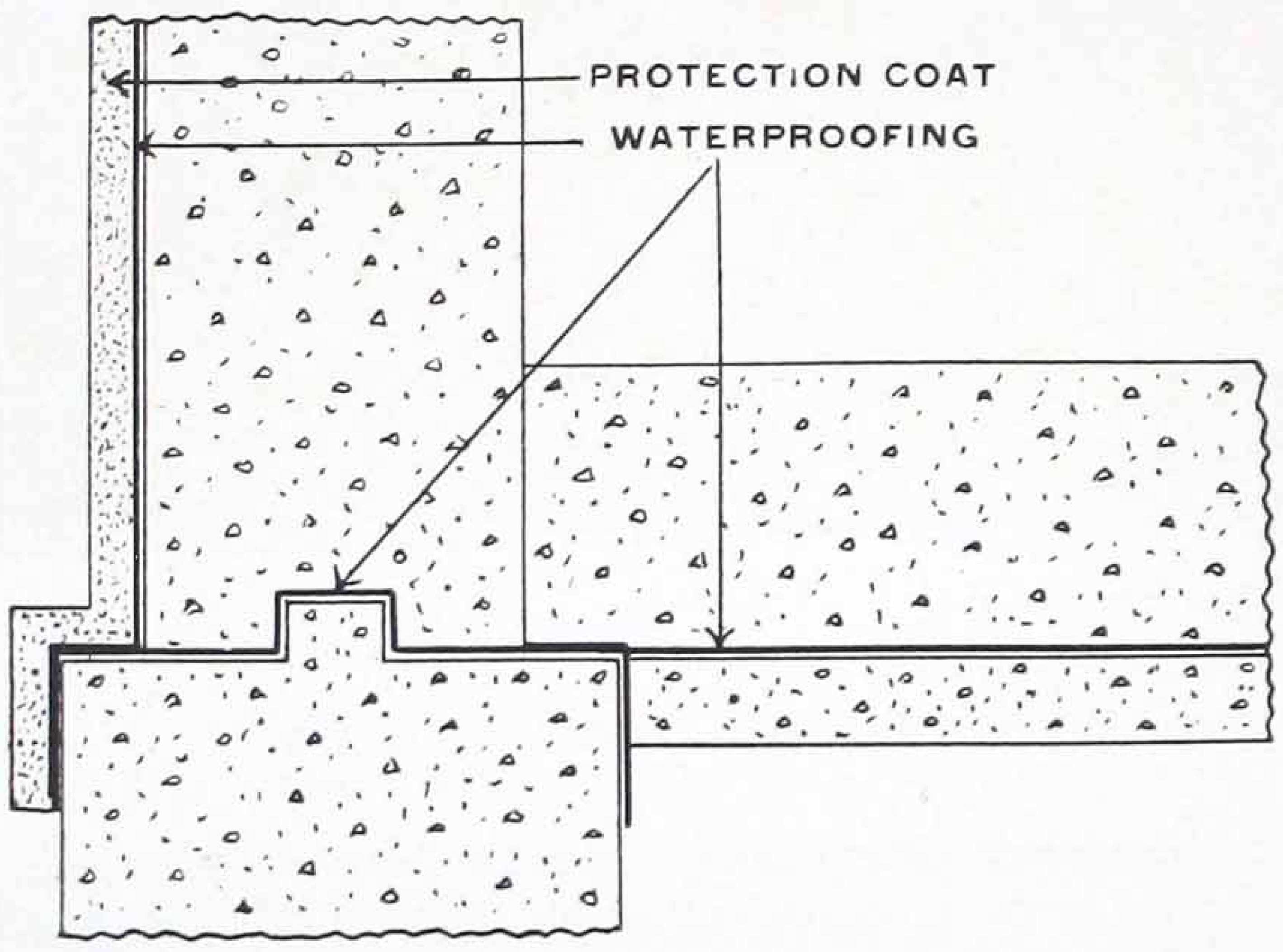


FIGURE 1

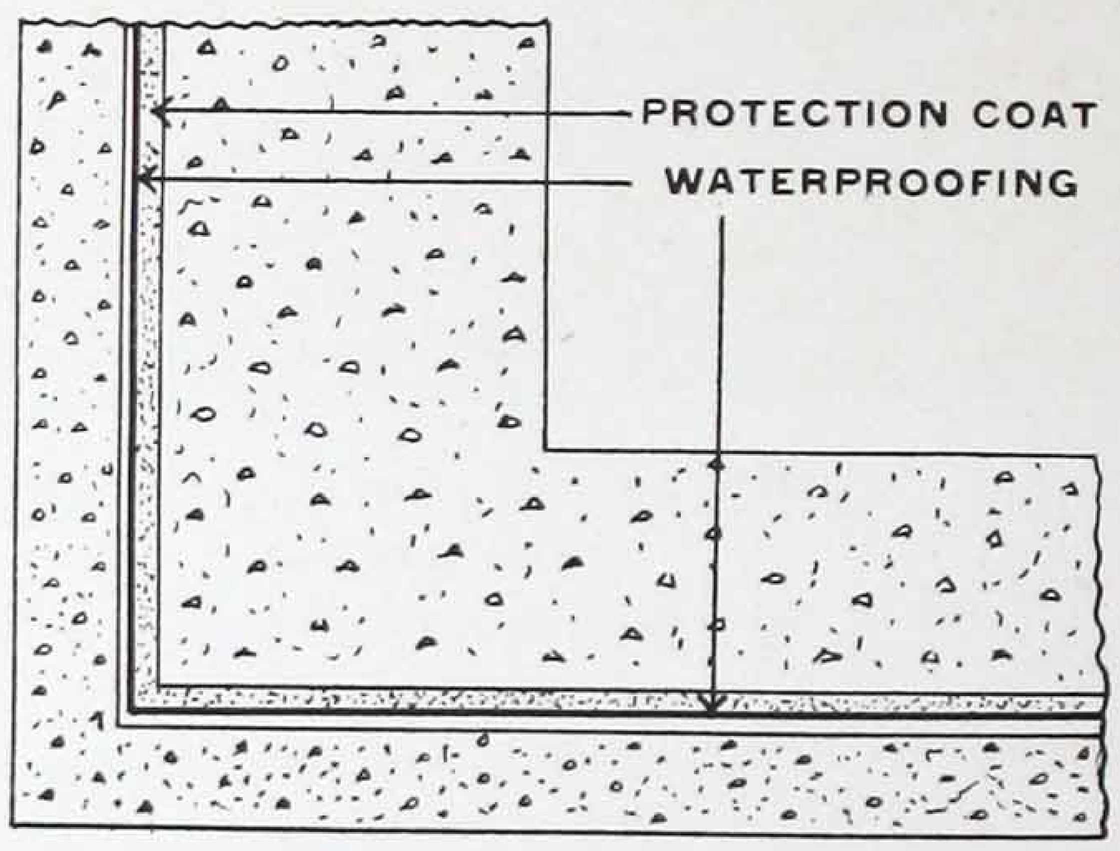


FIGURE 2

The usual method of waterproofing a building foundation by the membrane method is shown in Fig. 1 above. The footing is first waterproofed, the waterproofing being carried down both on the inside and the outside faces. That part of the waterproofing which extends beyond the wall is protected either by a scratch coat of mortar or by placing a board over it so that it will remain intact and permit of good connections with the wall and the floor courses. After the wall is cast, the mortar should be removed from the footing course and the wall waterproofing carried well down over the footing course and thoroughly sealed as shown. A protection course should then be placed immediately. The floor waterproofing should be similarly handled. The laps to which both floor and wall waterproofing are joined at the footing should be very carefully cleaned off and every precaution taken to insure a perfect connection, as these are the most vital points in the entire waterproofing plan.

Conditions occasionally make necessary a different method of construction of a foundation and consequent differences in the waterproofing plan. The first plan contemplates an excavation beyond the main wall sufficient to enable workmen to place the waterproofing. Abutting buildings or the location of the building line with respect to the street, may make it impossible to carry the excavation the additional distance necessary. In this case a wall either of brick or concrete is laid up against the cut, the waterproofing being placed on the *inside* of this wall, as shown in Fig. 2. The main wall is then cast, using the thin wall as a back form for the concrete. In such construction care must be exercised that the thrust of the liquid concrete does not bulge the back wall, as this might cause the waterproofing to rupture. If necessary the back wall should be braced sufficiently to stand this thrust.

SWIMMING POOLS

The waterproofing of a swimming pool presents few points of difficulty. Because of the damage which may result from even very small leaks, however, the work must be done with great care and the flashings both at the top of the pool and around the outlets must be made absolutely secure. The cut shown in Fig. 3 is a typical section of such work. The most satisfactory method of terminating the waterproofing at the top is to turn it well under the surrounding floor slab, casting the floor on top of it. This will lock it in place and prevent water from getting behind it. It is good practice indeed, to waterproof under the surrounding floor from wall to wall, turning the waterproofing up the wall somewhat above the finished floor level and covering it by coving the floor at the wall line. The additional expense is small and in the usual case is more than justified.

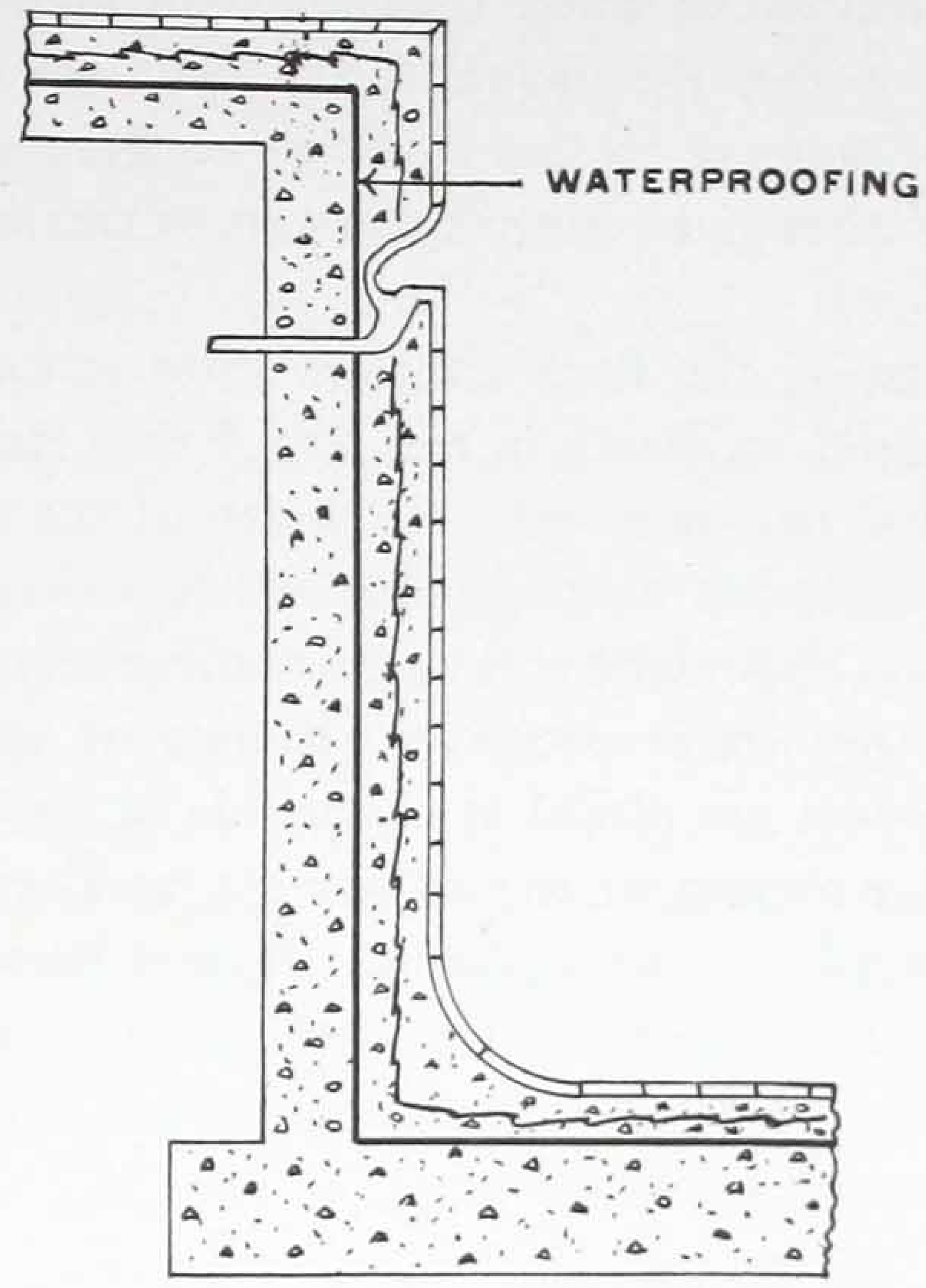


FIGURE 3

RESERVOIRS AND DAMS

Impounding water is an expensive operation, and every gallon of water lost through leakage represents a definite loss in money value. In addition to this, such leakage may and often is a source of annoyance and discomfort to a community by causing the failure of an adequate water supply. For this reason it is becoming more and more common to waterproof thoroughly the interior of reservoirs. Continuous high pressures and the numerous construction joints make waterproofing necessary if leakage losses are to be avoided.

Dams present the same general conditions, so that what is said of reservoirs applies to them with equal force, except for such modification of details of design as the general plan of construction makes necessary.

Provision must be made for locking the waterproofing firmly at the top to prevent it from slipping. This can be most effectively done by carrying it over the top of the reservoir and placing or casting the coping over it. A scratch coat of mortar should be applied over this horizontal lap to prevent the coping stone from shearing or cutting the waterproofing.

The expansion joints in the floors of reservoirs have always been a source of trouble. The detail of such joints should provide for the anticipated movement in such a way that all unnecessary tensile stress on the waterproofing will be eliminated. This can be accomplished by folding the waterproofing down into the joint, filling the joint afterwards with a good expansion joint cement. The direct pressure

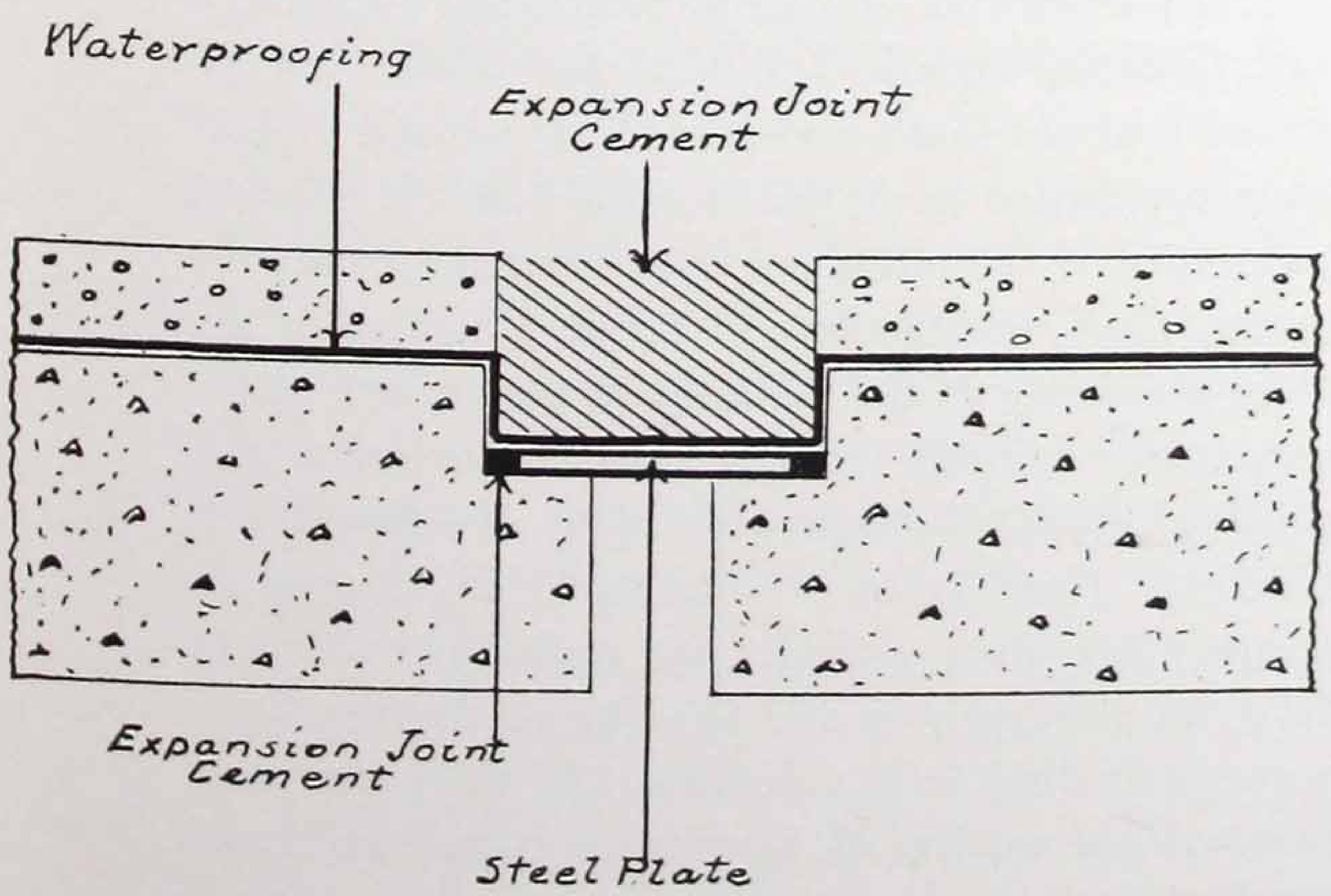


FIGURE 4

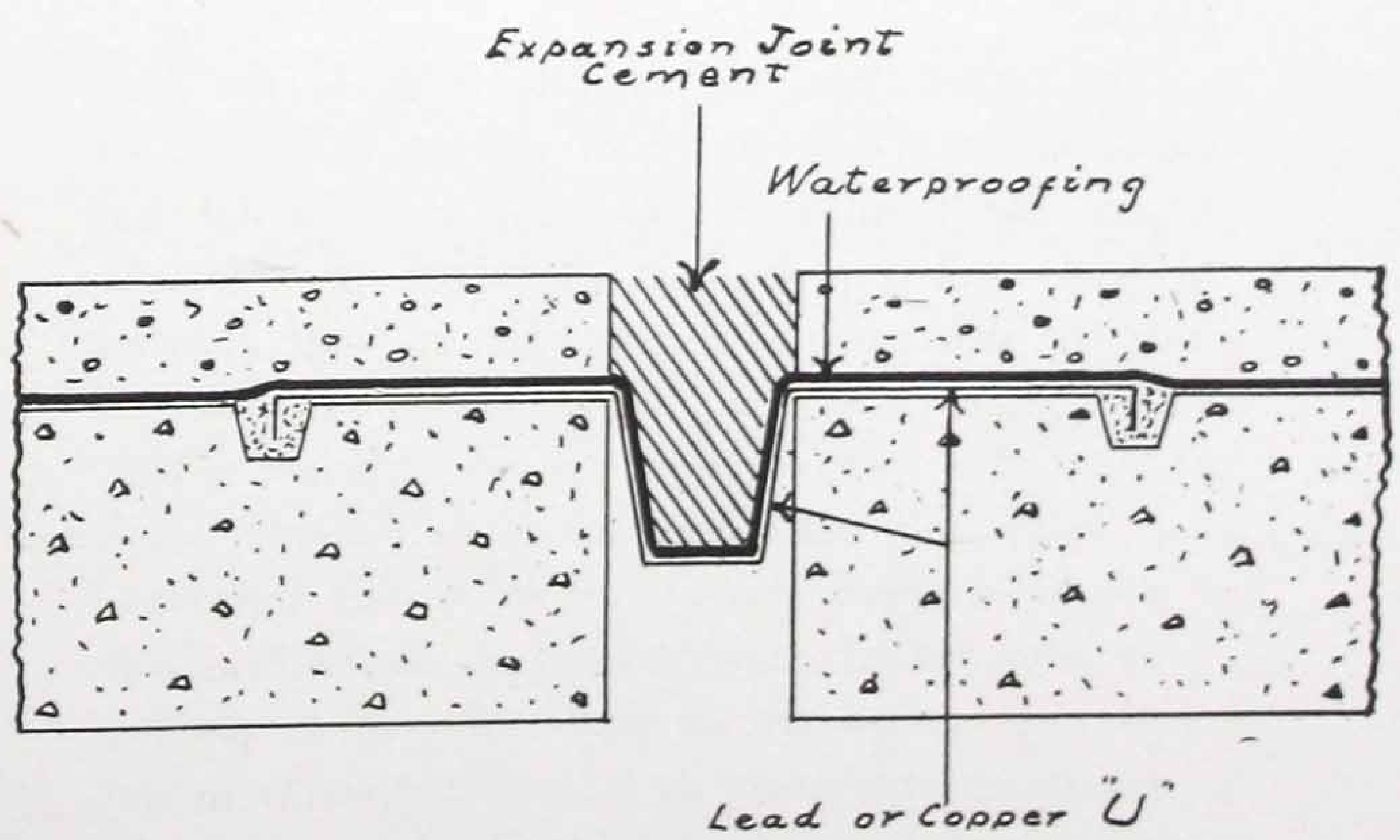


FIGURE 5

of the column of water over the joint makes necessary, however, the inclusion in the design of some form of support to this fold in the waterproofing. The sketches given suggest methods of treating these joints.

In casting the floor slab, an offset is formed in the concrete as shown in Fig. 4. A thin steel plate, somewhat narrower than the width of the offset, is then placed, first dipping it in the hot waterproofing asphalt. This plate will support the waterproofing against the water pressure. Buffers of expansion joint cement are placed at either side of the plate to allow for movement and so prevent buckling. The waterproofing is then placed, followed immediately by the protection coat. The entire recess to the level of the top of the protection coat is then filled with an expansion joint cement.

In casting the floor slab a reglet is formed as shown in Fig. 5. A lead or copper "U" is then formed, the ends of which are turned down into the reglet and thoroughly caulked. The waterproofing is then placed, being carried well down into the "U" as shown. Expansion joint cement is then poured in until the joint is filled. In this case the weight of the column of water is carried by the lead or copper.

The protection coat should be placed as soon as possible after the waterproofing to minimize the possibility of the latter being punctured or ruptured. On the sides, the protection coat, if of concrete should be reinforced with wire mesh which should be carried under the coping, as done with the waterproofing blanket, so as to relieve the latter from any drag incident to the weight of the concrete.

WATERPROOFING SOLID FLOOR BRIDGES

What has already been said as to waterproofing against pressure applies with equal force to the waterproofing of earth filled solid spandrel concrete arch bridges. Pressure is present—a maximum at the piers, a minimum at the crown of the arch. The problems then, have, in a sense, the same character but differ only in degree. The same principles therefore, apply to both, and the type of material best adapted to one is likewise best adapted to the other.

The other types of concrete bridges—the open spandrel on which the floor system is carried on arches and transverse spandrels, and the flat slab bridges—and steel bridges, introduce new elements into the discussion. A principle of waterproofing such structures may be laid down with but little fear of successful contradiction. That principle is this:

Wherever waterproofing is to be used under conditions such that it can be readily influenced by atmospheric temperature, it should be, in its physical properties, as little affected by fluctuations in temperature as is consistent with permanence and complete stability.

In other words, the first consideration is permanence. That can neither be sacrificed nor compromised. After that, however, the material should neither be excessively brittle nor excessively soft at the extremes of temperature to which it is sure to be subjected. The only type of bituminous product that fills this requisite is found among the asphalts.

On this point, Committee S-2 on Reinforced Concrete Highway Bridges and Culverts, American Concrete Institute, stated in its 1921 Annual Report:

"At present this limits the field to the bituminous compositions, asphalt and coal tar pitch. As between coal tar pitch and a properly refined asphalt your committee is of the opinion that the physical properties of the latter are better suited to meet the outstanding requirements of service; because of the close proximity of the material to the surface of the structure, it is subjected to structural movements and shock of impact through wide range of temperature. Coal tar pitch is more susceptible to changes in temperature than asphalt; its consistency changes from an extremely brittle solid at 40 degrees F. to a very soft fluid at 115 degrees. At the lower temperature the quality of ductility is completely lacking."

The following table in which a camparison is made between coal tar pitch, the American Concrete Institute's suggested specification and KARNAK Asphalt, illustrates the disadvantages under which coal tar pitch labors.

	Penetration		Ductility		% of	Weight Loss thru	Penetration
Amer. Conc. Inst.	32°	115°	40°	77°	Bitumen	Heating	Loss
Tent. Spec.	11+	100—	3+	15+	98	1%	25%
Coal Tar	3	175	0	100	74.5	1.8%	43%
Karnak	14	98	6	50	99.9	.06%	7%

In the same report this committee suggested a particular specification as the minimum requirements that should be exacted.

In addition, however, to the point raised by this committee as to the friability of coal tar pitch at low temperatures, the extreme softness of that material at a temperature of 115 degrees and even below operates against its efficiency. At that temperature the material is entirely lacking in cohesion and is impossible to hold either on slopes running up to the girder on steel bridges or on the vertical rises at the curb flashing on concrete bridges.

Again the opening of joints in cold weather through contraction demands a waterproofing material which can be slowly bent and which can yield without fracture to the stresses imposed on the waterproofing blanket. But in cold weather, coal tar pitch has neither plasticity nor ductility. It is therefore in no sense adapted to bridge waterproofing.

The properties of KARNAK asphalt are shown in the comparative table above. The relative softness at 32 degrees F., the ductility at 40 degrees F., and the relative stiffness at 115 degrees F. are the features which distinguish it physically from coal tar pitch.

Extreme caution must be exercised, however, lest in an endeavor to obtain desirable physical properties other and more important qualities are sacrificed. It is entirely possible to so refine an asphalt that it will be still more plastic at 32 degrees F. and stiffer at 115 degrees F., than is KARNAK,—a combination of properties which is still more attractive. But this can be done only by considerably increasing the oxidization of the asphalt, by more intensive "blowing." This will occasion a very sudden drop in the ductility at 77 degrees F. with loss in adhesive value and of self healing capacity.

But aside from this disadvantage, such a change at once threatens the permanence of the product because of the danger of overoxidization, or forcing into the asphalt more oxygen than it can absorb. If this is done, the asphalt will in a relatively short time begin to exude oil, lose its coherence and become cheesey.

It is not believed that the difference in consistencies between 32 degrees and 115 degrees in our specifications can be appreciably lowered without entering the danger zone.

As to the membrane, what has been previously written applies with even greater force and emphasis to waterproofing bridge floors. In particular is this true with regard to the necessity for elasticity. Two conditions will serve to make this necessity apparent.

a. If cracks develop in the floor slab, the entire waterproofing course—membrane and asphalt—must stretch so as to span the cracks without rupture.

b. The dimensions of the floor slab are not fixed, but vary with temperature changes. While the variation, as far as waterproofing is concerned, is eventually taken care of at the expansion joints, there is nevertheless a movement affecting the waterproofing which cannot be so provided against. In each slab section this movement begins at the center and acts towards the expansion joints at either end, each unit of length of concrete (whatever unit may be assumed) having its own movement.

In Fig. 6, for example, AB represents a slab, the center of which is at C, with expansion joints at A and B. a, a′, a″, etc., are the assumed units of length. At any point between C and B, say at D, the movement which occurs is the integration of the movements that occur in a, a′, a″, etc. This produces an accumulating stress on the waterproofing which reaches its maximum at B, where it is suddenly relieved. Until B. is reached, however, this stress must be taken up by the waterproofing itself. In other words, there must be sufficient elasticity in the waterproofing course to enable it to stretch without breaking over this increase in length.

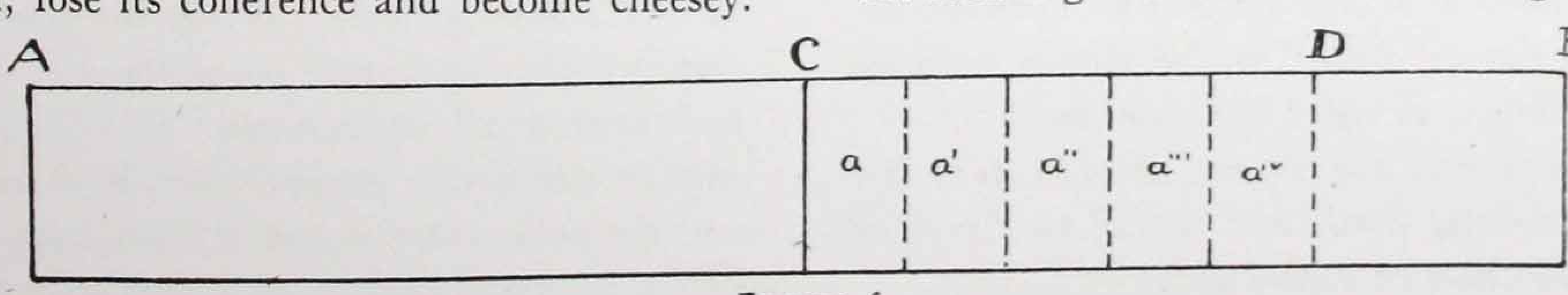


FIGURE 6

STRENGTH OF MEMBRANE

As to strength it may be said that there is a tendency with some manufacturers to greatly exaggerate the strength requirements of a fabric for bridge waterproofing. The only way in which it is apparent that strength functions is this:

The membrane is encased in a plastic medium—the asphalt—and the entire blanket is imprisoned between layers of concrete under a maximum compression in service of not more than 10 pounds to the square inch. If the distance between any two points on the concrete should increase—as by the development of a crack—the membrane should be sufficiently strong to distribute the stresses produced through the asphalt over a sufficient area to enable the elasticity of the cloth to function, and so prevent the localization of these stresses at the line of the crack. An elaborate series of tests on just this point were recently conducted by the Pittsburgh Testing Laboratory for one of our largest railroad systems, in which service conditions as to application of the material, compression, and the development of a crack were simulated as near as may be in a laboratory. The result showed conclusively that the strength requirements of our specification are ample for all working needs. Additional strength, which is quite unnecessary, can be obtained only by using a heavier fabric with a corresponding increase in cost.

METHODS AND DESIGNS

The successful waterproofing of any bridge, whether of steel or concrete, depends initially on the design. The best material to be obtained, applied with perfect workmanship, cannot produce water tight results on a bridge which was not designed to be waterproofed. The design of the waterproofing details must, therefore, be the initial step of the bridge engineer who wishes to protect his structure from the deteriorating effects of water penetration.

It is impossible in a booklet of this kind to show waterproofing details applicable without change to all of the many types of bridges that are being constructed. A few typical designs will be indicated in the hope that they may contain suggestions which may be modified to meet particular problems as they arise.

At the outset, certain basic principles may be laid down which lie at the bottom of successful waterproofing of any bridge, whether of steel or concrete.

1. The general design should be such as will take the water off the bridge as quickly and as rapidly as possible.
2. Waterproofing should be regarded as an accessory to a proper drainage system, its function being to convey water to the drains without permitting it to enter the concrete.
3. The openings into the drains should be at the waterproofing level, and not at the level of the protection or armor coat.
4. The most dangerous points in every bridge are the lines of termination of the waterproofing. Whether around downspouts, against curbs, or against the web of a steel girder, a means of flashing must be provided which will furnish a permanent seal behind which water cannot find its way.

The problem of obtaining water-tight results is much more difficult on steel bridges than on those of concrete. In particular does this apply to the most common form of steel bridge—the railroad bridge carrying ballasted tracks. The most persistent source of trouble is the flashing against the web of the girder. The difficulty is caused by the stiffeners, brackets, knee braces, etc., which project from the girder as well as by the fact that, because of the vibration, the concrete almost invariably shrinks away from the girder. Many expedients have been adopted to prevent the water which comes down the girder from getting behind the waterproofing at this point and so reaching the steel members.

The detail shown in Fig. 7 on the next page is used widely by several railroads. It is a much favored detail of the Philadelphia & Reading, particularly on deep girders. When the base concrete is cast, a groove is formed along the web of the girder and around all projections. The waterproofing is carried down this groove instead of up the girder, and the pocket that is left is filled with strongly adhesive asphaltic cement of a character that will re-

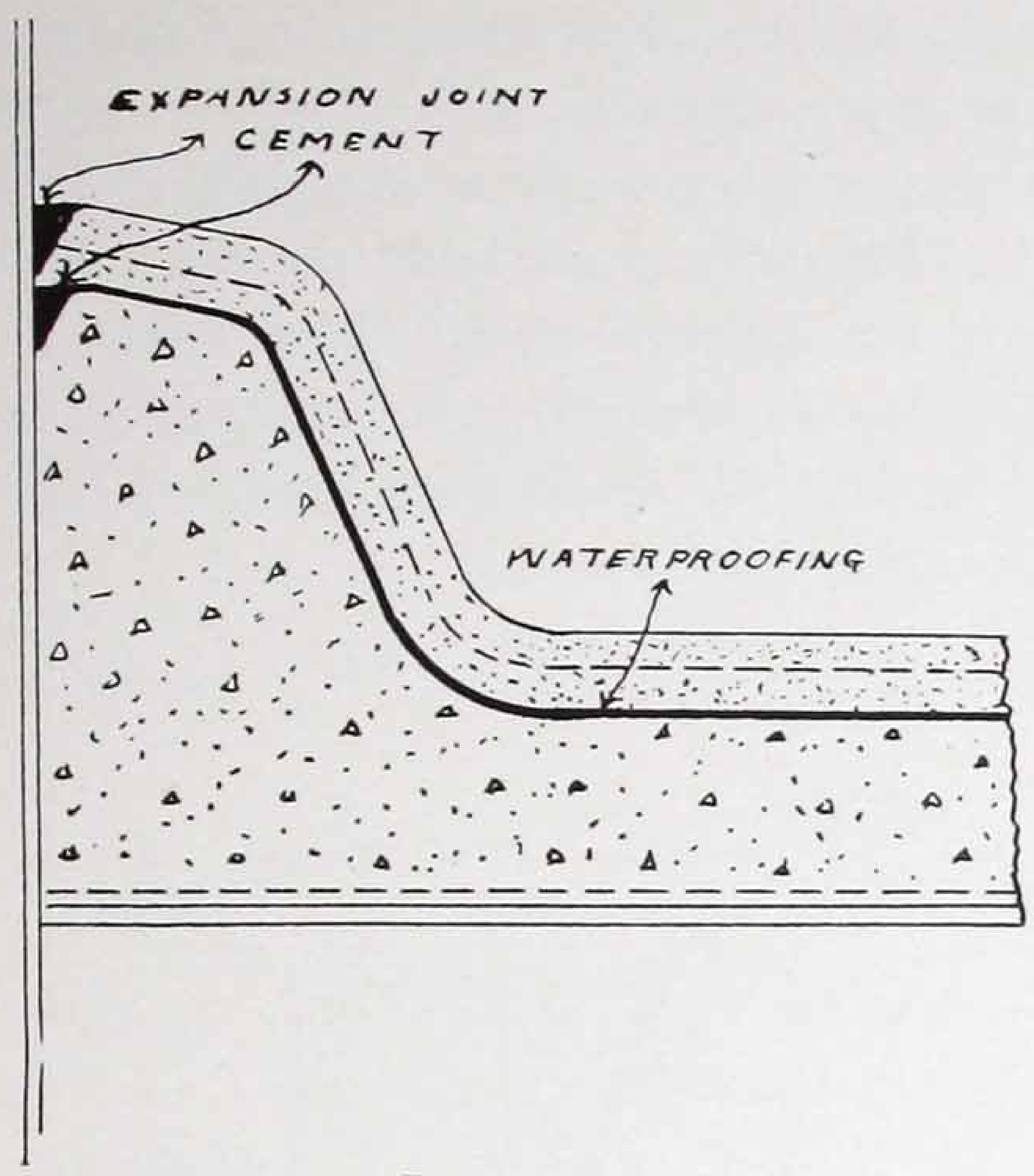


FIGURE 7

main plastic and elastic through a very wide range or temperatures.

Another method of flashing which has been used with success, notably by the New York Central Railroad on a large bridge at Carthage, New York, is to carry the concrete base up the underside of the top flange of the girders, completely encasing the brackets and stiffeners, so that the surface to be waterproofed is unbroken. The waterproofing is then carried up the sides of the concrete base to the top flange which thus acts as a watershed. This method, however, is not adapted for use on deep girders because the mass of concrete involved would greatly increase the dead load.

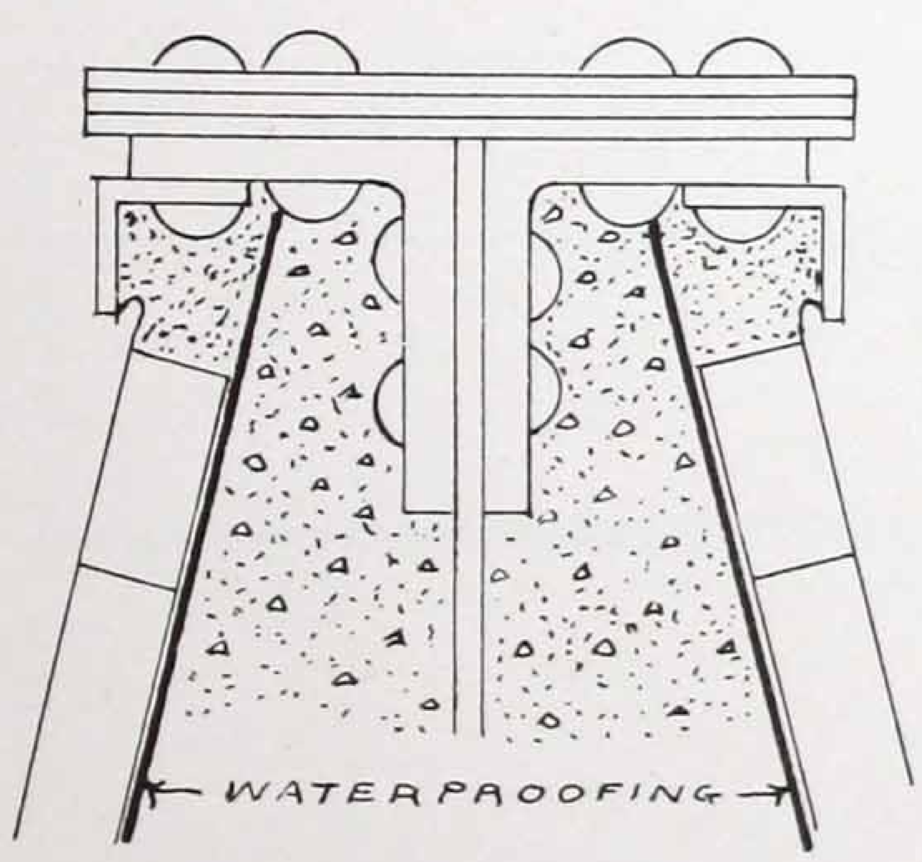


FIGURE 8

The Long Island Railroad has used with excellent results a combination of this last method with the drip angle as shown in Fig. 8. This prevents the water which falls on the flange from being drawn by the capillarity in the protection coat, along the underside of the top flange and so behind the waterproofing.

CONCRETE BRIDGES

The design of the waterproofing details of a concrete viaduct presents a much more simple problem than in the case of a steel bridge. The surfaces are flat or but slightly sloped, the flashings elementary. The same general principles noted on page 28 of this booklet must, however, be applied.

It is necessary to consider but two types of structures—those with earth filled solid spandrels, and those with open spandrels in which the floor system is carried on arches and transverse spandrels or on beams.

In the first type, the waterproofing problem is that of waterproofing a series of earth-filled buckets formed by the successive arch rings and the spandrel walls. In such bridges there is excellent natural drainage which conveys water very rapidly to the drains, the latter usually taking the form of weep holes at the piers. It is particularly important that this type of bridge be thoroughly waterproofed, as such water as percolates into and through the earth fill is under direct pressure in a degree varying with the depth of the earth fill.

The waterproofing plan is simple. The waterproofing blanket should be a continuous and unbroken sheet over the arch rings and across the piers, and up the inside of the spandrel walls to the sidewalk level. Close fitting connections should be made at the drains to prevent water working under the waterproofing and backing up over the arch rings.

Where the waterproofing terminates on the spandrel wall it should be well anchored to prevent slipping.

The waterproofing is carried over the arch rings and up the spandrel walls, turning into the parapet at the level of the sidewalk slab. Instead of casting the sidewalk slab into the recess left for the waterproofing, this recess may be filled with a brick laid on edge and pressed firmly into place with an expansion joint along the base of the parapet.

The protection coat should be gravel concrete, 1:3:5, reinforced on the slopes of the spandrel with wire mesh.

In designing an open spandrel or other type of flat slab bridge, the first point to receive attention is to pitch the floor towards the drains both transversely and longitudinally. This necessitates great care in the design of the flashing around the drains, the precise method of flashing depending on the type of drain used. The design, however, must be made with the realization that there will be a heavy

flow of water at these points and provision must be made against water finding its way under the waterproofing and working up over the floor. A second danger point is at the expansion joints. No matter what type of membrane waterproofing is adopted, it is always sound practice to eliminate as far as possible all tensile stress on the waterproofing envelope. This means that at the expansion joints, then placed, the edges being turned down into the reglets and caulked securely in place. It was thus assured that all movement would take place in the "U," and that the edges could not slip and puncture or tear the waterproofing. The latter was then placed, being carried in an unbroken sheet well down into the "U," the space being then filled with an expansion joint cement.

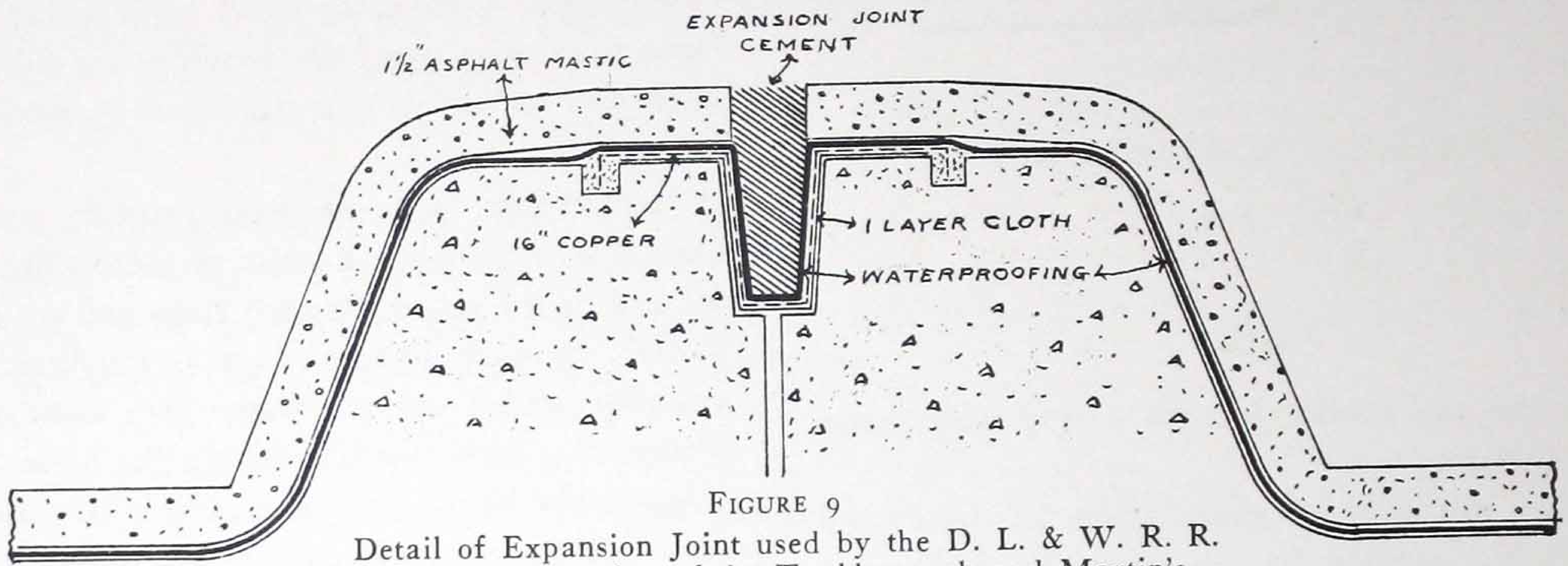


FIGURE 9
Detail of Expansion Joint used by the D. L. & W. R. R. in the construction of the Tunkhannock and Martin's Creek Viaducts

provision must be made for the elongation of the envelope as the joint opens through contraction of the slab. This can be done by folding the waterproofing into the joint. Illustrated below are two types of joint which have been used with success. They have the merit of extreme simplicity, ease of construction, and can be readily reached for maintenance purposes should repairs ever be necessary.

In Fig. 10 the joint is fundamentally the same as that shown in Fig. 9, the difference being only in detail. An offset is left in the concrete protection coat, in which is placed a steel plate, the function of which is to keep gravel or pieces of the asphalt paving from getting into the "U" and being crushed into the waterproofing as the slabs come together. Buf-

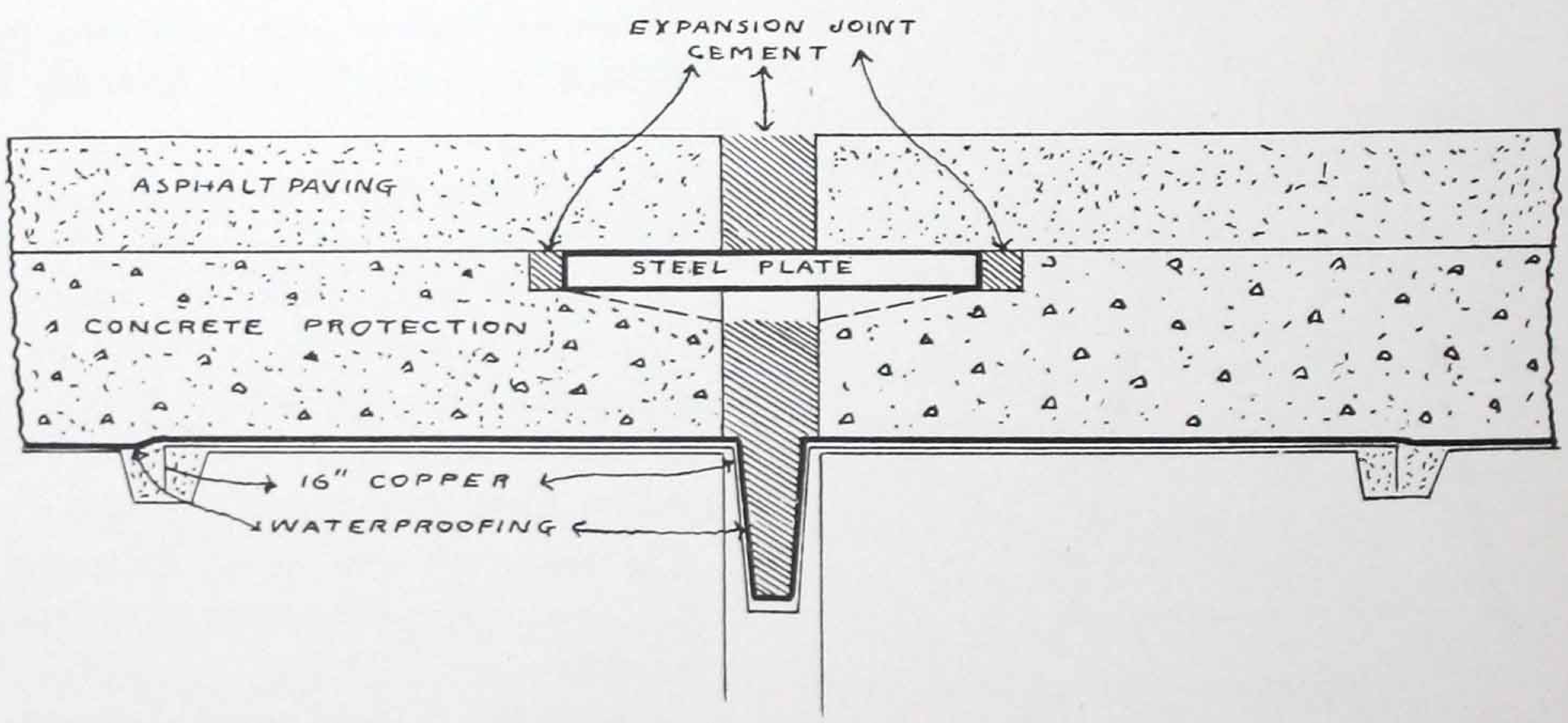


FIGURE 10

The floors of Tunkhannock and Martin's Creek viaducts are broken by dykes, the expansion joints being at the dykes. In casting each dyke a reglet was formed as shown in Fig. 9. A single ply of asphalt saturated cloth was first laid to form a bed for the copper "U" to rest on. The copper was fers of expansion joint cement are formed at either side of the steel plate to prevent buckling. Should any vertical movement be anticipated, the base of the offset in the concrete protection coat should be sloped as indicated by the broken line so that the plate could pivot on an edge.

The flashing at the curb is a detail of the utmost importance. The line of intersection of the floor and the sidewalk curb usually serves as a gutter along which water runs to the drains. Thorough provision must be made at this line to prevent water from getting behind the waterproofing and coming through to the soffit of the arch. There are various methods of accomplishing this, the most positive of results being the use of a flashing strip of copper, lead or other suitable material which is turned down over the vertical turn-up of the waterproofing after it has been placed. Suggested details are shown in Figs. 11 and 12.

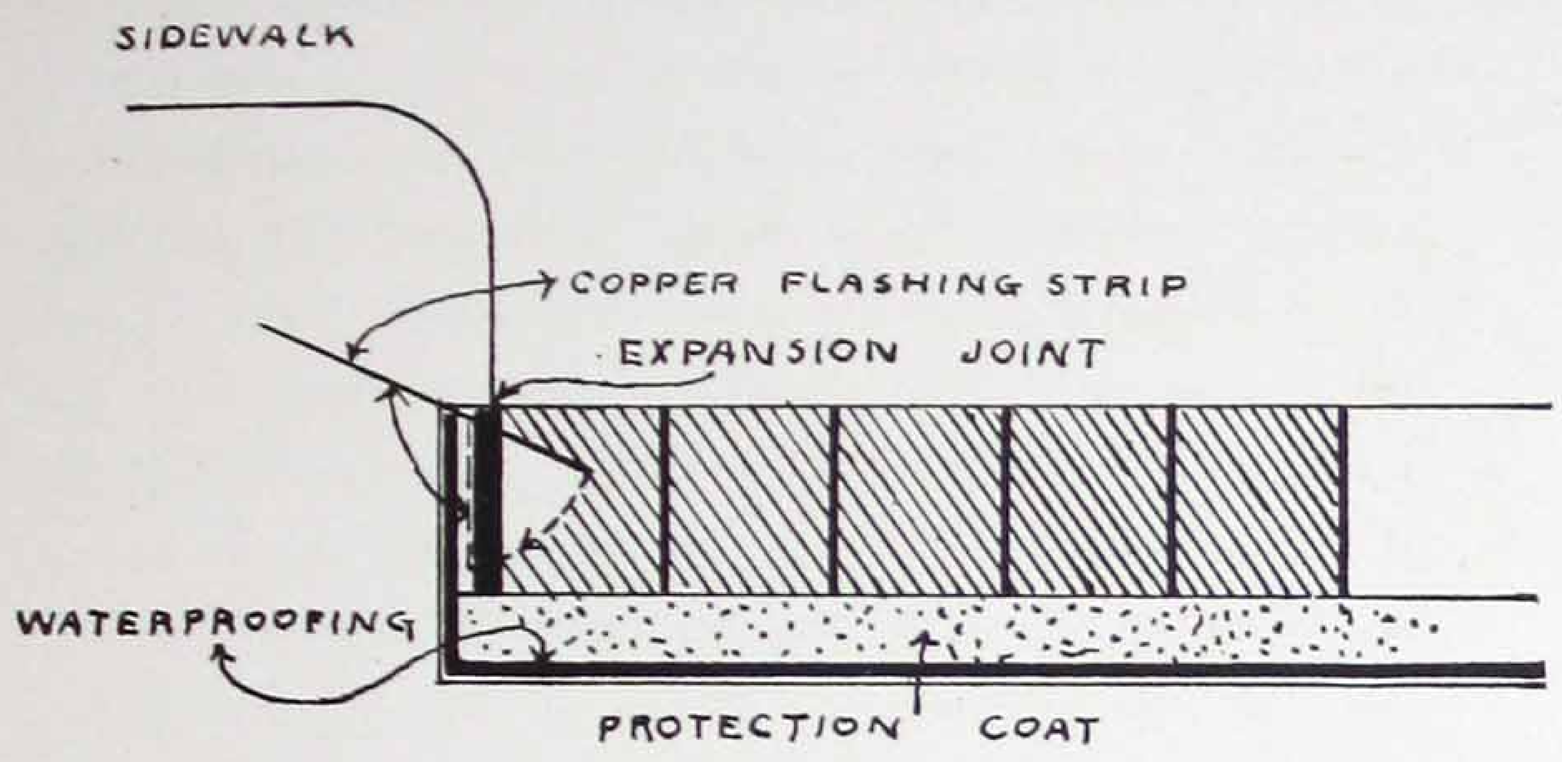


FIGURE 11
Detail of flashing at the curb, showing use of copper strip turned down over waterproofing

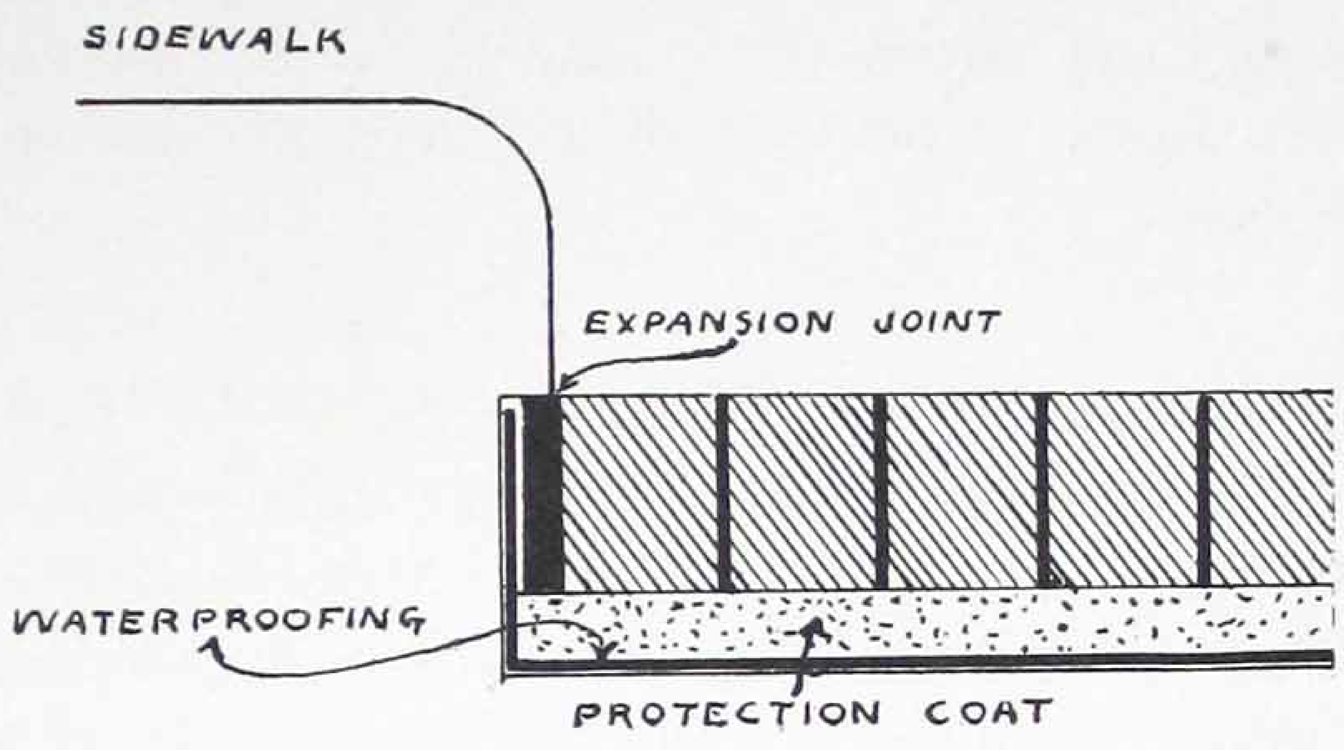


FIGURE 12
Detail of flashing at curb without flashing strip

TYPICAL INSTALLATIONS

The illustrations in this booklet are sufficient. we think, to indicate the high regard in which KARNAK waterproofing is held throughout the country. It has been repeatedly selected above all competing materials by some of the leading engineers of the country solely on the basis of its uniformly high quality and efficiency. In addition to the installations shown in the illustrations, the following may be cited:

CHICAGO, BURLINGTON & QUINCY R. R.

The entire East Aurora, Illinois, improvement of this road was waterproofed with KARNAK materials. The selection of materials was made as the result of a report of one of the country's leading bitumen technologists. Unmarked samples of several materials were tested by this authority whose report was entirely favorable to KARNAK materials.

CHICAGO UNION STATION

KARNAK materials were selected for the Canal Street section of this work, which is one of the most colossal railroad developments ever undertaken in the middle west. Selection was made entirely on the quality of material. Samples of different materials were tested by two of the country's leading laboratories, the result of whose report was the selection of KARNAK cloth and asphalt.

UNITED ELECTRIC LIGHT & POWER CO., NEW YORK

The electrical galleries of the new power station of this company—and this power station is the largest of its kind in the world, costing upward of $20,000,000—were waterproofed with KARNAK materials. This station, at 134th Street and Locust Avenue, New York, is directly on the Bronx River so that any subsurface work is subject to water pressure.

CHICAGO & NORTHWESTERN RAILROAD

All of the 1923 improvements of the Chicago & Northwestern Railroad will be waterproofed with KARNAK Fabric and KARNAK Asphalt. This road is the pioneer in waterproofing among the railroads centering in middle western points. It was one of the first to appreciate the necessity of waterproofing railroad structures, and has followed the development of waterproofing materials more closely, probably, than any other western road. That, with this background of long experience and careful study, it has selected KARNAK materials for its 1923 improvements, is to us an eloquent tribute to the success of our efforts to produce the highest grade materials, and to the superiority of ours over similar imitative materials.

D. L. W. R. R.

All of the extensive improvements of this road throughout New Jersey during 1921 and 1922 were waterproofed with KARNAK Fabric and KARNAK Asphalt, the selection of materials being made essentially on the basis of superior quality.

N. Y. C. R. R.

The large steel bridge of the New York Central Railroad over the Hudson River at Castleton, N. Y., (now under construction) will be waterproofed with KARNAK Fabric and KARNAK Asphalt. This structure is over 4000 feet long and is about 30 feet wide.

VEHICULAR TUNNEL UNDER THE HUDSON RIVER

The bottom of the Canal and Spring Street shafts of this work were successfully waterproofed with KARNAK materials. The waterproofing was placed 60 feet below street level and at least 50 feet below the level of the river.

OTHER CONSISTENT USERS OF KARNAK MATERIALS

New York Central Railroad.
Baltimore & Ohio Railroad.
Erie Railroad.
Philadelphia & Reading Railroad.
Chicago & Northwestern Railroad.
Chicago & Alton Railroad.

UNALTERABLE PRODUCTS

OTHER KARNAK PRODUCTS

Karnak Roofing Materials	[Bulletin No. 5]
Karnak Joint Fillers Karnak Dampproof Paint Karnak Stone Backing Karnak Brush Plastic Karnak Trowel Plastic Karnak Caulking Rope	[Bulletin No. 41]